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TABLE OF CONTENTS.

ENGINEERING NEWS OF THE WEEK.....17, 31, 32
The Sinking of a Steamship at Sea (illustrated).... 18
The Steel Dome for the Yerkes Observatory, Lake Geneva, Wis. (with two-page plate)..... 18
Notes from Recent Water-Works Reports..... 19
Carrying a Steel Pipe Sewer Across a Bridge at London, Ont. (illustrated) 21
Track Elevation and Depression at the 16th St. Crossing, Chicago (illustrated) 21
A New Formula by Bazin for Computing Flow of Water in Open Channels (illustrated)..... 26
A Modern Electric Central Station (illustrated).... 28
A Steam Engine with Oscillating Piston (illustrated). 29
The Increase in the World's Principal Navies..... 29
Test of a Pipe Distribution System 30
The Erection of a Bridge Over the North Railway in Paris (illustrated) 30
The Cost of Producing Power at the Lachine Rapids Electric Power Plant. 31
Book Reviews 32
EDITORIAL NOTES 24
Lessons of the Santiago Battle to Naval Designers—The Results of American Inventive Genius in the Wire Rod Industry—The Influence of the Electric Railway on the Growth of City Suburbs—An English Engineer on the Use of Garbage as a Fuel for Electric Light Stations—"English as She is Wrote," by a German Translator.
EDITORIAL:
The Prevention of Steamship Collisions..... 25
LETTERS TO THE EDITOR 26
Note on the Behavior of Some Cements with Dilute Hydrochloric Acids—The Effect of Temperature on the Flow of Water Through Soils.

THE JAPANESE PROTECTED CRUISER "KASAGI," built at the Cramp's shipyards in Philadelphia, had her contract trial trip on July 12, and with rough water and a strong tide setting almost at right angles with the course, a mean average speed of 22.75 knots per hour was developed. The course was 20 miles long, in four legs, and the following table shows the results of the run up and down the course, a total of 40 miles:

Run up.	Elapsed time. min. sec.	Speed. Knots.
First lap	12:54	23.25
Second lap	13:07	22.90
Third lap	13:00	23.07
Fourth lap	13:00	23.07
Total interval, 52:00. Average, 23 knots.		
Run down.		
First lap	13:14½	22.65
Second lap	13:14	22.67
Third lap	13:33	22.12
Fourth lap	13:19	22.55
Total intervals, 53:20. An average of 22½ knots. Mean speed for the run, 22.75 knots.		

The revolutions rose from 158 at the beginning of the run to 164 at the end. To show the perfect condition of the machinery a series of progressive trials was run as soon as the main trial was over, in order to get the speed at 80, 125, 150 and 162 revolutions. The "Kasagi" is 374 ft. long and 48 ft. beam, and is one of the heaviest armed cruisers of her size afloat. She will carry two 8-in. breech-loading rifles and ten 4.7-in. rapid-fire guns. The vessel was completed six months ahead of the contract time.

THE LAKE STEAMER "HENDRICK S. HOLDEN" was launched at the yard of the Globe Iron Works Co., of Cleveland, O., on June 25. This vessel is 430 ft. long and 410 ft. keel, 50 ft. beam and 28 ft. deep. The hull is built of mild steel and her masts are also steel; she has twelve cargo hatches spaced 24 ft. between centers. Her quadruple expansion engine has 20¼, 30¼, 44 and 63½-in. cylinders with 42-in. stroke. The three Scotch boilers supply steam at 230 lbs. working pressure, and these boilers are fitted with the Ellis & Eaves system of induced draft. The carrying capacity of the vessel is 5,500 tons.

BROOKLYN DRY-DOCK NO. 3 has been officially declared safe and ready for use by Mr. P. C. Asserson, C. E., U. S. N., in charge of the Brooklyn Navy Yard. Naval Constructor F. T. Bowles, U. S. N., in charge of the repairs, is now relieved from further responsibility. The coffer-dam at the entrance has yet to be removed, and the entrance will then be dredged out to the full depth.

THE LAKES ST. CLAIR AND ERIE SHIP CANAL project, says the New York "Sun," is again attracting attention, and there is a prospect that active work may be commenced upon it within a year. The line of the canal, commencing in the channel in Lake St. Clair and about 5 miles from the head of the Detroit River, would pass 17½ miles over the "Flats" to the shore line; the actual cutting across the neck of land to Lake Erie is about 14 miles, and the mouth of the canal on the latter lake would be about 60 miles easterly of the usual route through the Detroit River, with an actual saving in distance of 79 miles. The estimated cost of the canal is $5,500,000, and it could be built in two years. The promoters figure that a toll of 3 cts. per ton would be sufficient to make the enterprise a paying one, provided two-thirds of the tonnage now passing Detroit could be deflected to the new route.

THE MISSISSIPPI RIVER COMMISSION has made the following allotments for levee work, according to the Memphis "Commercial": Tensas District, $100,000; St. Francis Levee District, $34,000; the Upper Yazoo, $26,000; Lower Yazoo, $90,000. This latter is Major Wm. Starling's district.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a freight train collision on the Pittsburg & Connellsville line of the Baltimore & Ohio R. R., at Foley's, Pa., on July 9, in which one man was killed and six were injured. The accident was a head-end collision and, it is stated, was due to an error in the train orders. ——The collision of a freight train with a switching engine in the yards of the Pittsburg & Lake Erie R. R., near Pittsburg, Pa., on July 7, resulted in the serious injury of one man, the destruction of several freight cars, and considerable injury to the colliding locomotives.——A derailment at Ridgewood, N. J., on the Erie R. R. on July 9 resulted in injuries to the fireman and engineer and wrecked 26 freight cars. A westbound freight train was pulling out onto the main line at high speed when the locomotive jumped the frog, owing, it is thought, to the spreading of the rails. The cars crashed into the engine and were thrown from the track.

THE BROOKLYN BRIDGE TROLLEY SERVICE was blocked for 30 minutes on July 9, owing to the burning of one of the switch boxes used to control the power on the bridge by a stroke of lightning which grounded the wires. The box is of wood, about 2×3 ft. in size, and contains four switch levers, which connect or disconnect the current to different portions of the bridge. The explanation of the engineers is that lightning striking the electric wire on the bridge grounded the current, and formed an arc in the switch box, which destroyed it. The damage was intensified by the attempt to counteract the grounding by sending the full force of the current from the power house through the switch box.

AN EXPLOSION AT THE LAFLIN-RAND POWDER Works, at Pompton Lake, N. J., on July 9, caused the death of nine and perhaps of eleven persons, and wounded a number of others, besides destroying property amounting to about $30,000. Nine buildings were destroyed, including two mixing-houses, two guncotton-houses, the assembling-room, two traverses and the boiler and powder houses, the latter two being destroyed by fire. The first explosion, there being two, started in the northern mixing-house. In the mixing-rooms is a combination of guncotton, glycerine and nitric acid in process of manufacture. To the east of the mixing-rooms is a stone wall, 10 ft. high and 4 ft. thick, with an opening at about the center, through which the workers disappear and take refuge behind the stone wall when the machinery in the mixing-room is started. The men return to work after the machinery is started, and it was at this juncture, it is thought, that the explosion occurred. Captain Aspinwall, the Superintendent of the works, states that the mills will be delayed about two months in their orders. There were 60,000 lbs. of powder on the ground ready for shipment to the army when the accident occurred, but luckily this was not injured. Of the 47 buildings on the premises 38 are intact. The door of a building containing the store of guncotton was blown off, but the high explosive remained unharmed. An investigation has been commenced to determine the cause of the explosion.

FIRE DESTROYED THE STEAMER "DELAWARE," of the Clyde Line, off Barnegat, N. J., on the morning of July 9. All the passengers, 66 in number, including the crew, were saved by taking to the boats. The "Delaware" was a wooden vessel and was 19 years old. It is supposed that the fire started in a quantity of wood stored under the main saloon deck. When discovered the flames had gained so much headway that all attempts to put out the fire were found to be useless, and the whole attention of the ship's crew was turned toward saving the lives of the persons on board. The ship, which was some 10 miles from shore when the fire was discovered, was run in to within about 2 miles of the shore, and the passengers and crew transferred to the ship's boats, from which they were taken by the tug "Ocean King" to New York. Wrecking tugs, which were sent to the scene of the accident at once, attempted to tow the burned hull to New York, but after proceeding a short distance the hull sank off Point Pleasant, N. J.

A STREET CAR COLLISION in Washington, D. C., on July 10, resulted in the death of one and the injury of nearly 30 persons. The accident occurred opposite St. Elizabeth's Government Asylum for the Insane. A steep hill runs from the asylum into Anacostia, and the brake chain broke as the car started to make the descent. The motorman jumped without reversing his motor, and when the car reached the bottom of the hill it had gained a speed, it is stated, of 70 miles an hour. The horse car was standing on the turntable at the end of the line, and the driver jumped just in time to save his life. Many of the passengers were injured by jumping from the car during its flight down the hill.

A BROKEN PISTON ROD on the steamer "Lucania," of the Cunard Line, compelled that vessel to enter Liverpool on her last trip under one engine. The rod which broke belonged to the port engine, and the accident occurred on July 7. The passengers were in bed at the time and did not know of the accident.

THE STEEL INTAKE CRIB for the new intake tunnel of the Cleveland water-works was towed to place and sunk in position on July 1. The crib has an exterior diameter of 100 ft. and was sunk in nearly 50 ft. of water at a point some four miles from the shore. The inner wall of the crib forms a well 50 ft. in diameter. Between the inner and outer walls are water-tight bulkheads, 24 in number. The plates for both walls and the bulkheads are of ⅜-in. steel plates. The compartments will be filled with stone. The contractor for the crib is the Van Dorn Iron Works, of Cleveland. Mr. M. W. Kingsley, M. Am. Soc. C. E., is superintendent of the water-works and chief engineer of the new tunnel. Mr. C. F. Schulz is first assistant engineer of the water department.

ANOTHER ACCIDENT IN THE CLEVELAND WATER-works tunnel occurred on the evening of July 11, in which ten or eleven men are supposed to have lost their lives through a gas explosion. The men were at work under air pressure some 6,500 ft. from the shore shaft and just beyond the scene of an explosion that occurred on May 11, which caused the death of eight men.

STREET CAR FENDERS are to be used in Chicago if the new ordinance passed July 5 is carried into effect. Similar ordinances have been passed, but have been declared void by the courts to which the street railway companies appealed for relief. The present ordinance provides for fenders of the basket type, built of steel. Some of the companies' officials claim that the transverse plank in front of the wheels is all that is necessary and that basket fenders will be a constant source of danger.

PLANS AND ESTIMATES for a filtration plant for Philadelphia, to be made by the department of public works, and to be ready by Oct. 1, were ordered by the lower branch of the city council on July 11. The same body has indefinitely postponed consideration of an ordinance providing for the construction of a filtration plant.

THE FILTRATION OF THE WATER SUPPLY of Providence, R. I., is again under consideration by the city council, after having been dropped for a number of years. A review of the several plans for filtration and a critical abstract of a report by Mr. Edmund B. Weston, M. Am. Soc. C. E., Assistant Engineeer in Charge of the Water Department, was published in Engineering News for April 16, 1896.

THE BROAD ST. BRIDGE, over the Phila. & Reading Railway subway in Philadelphia, was opened to traffic on July 2. This bridge is 113 ft. wide, with 69 ft. in the driveway and two 22-ft. sidewalks. It is carried over the depressed tracks by a steel plate-girder structure of five spans, having a total length of 265 ft. and containing over 1,000 tons of steel. This bridge also carries beneath its floor five lines of 12-in. gas mains and 36 galvanized iron pipes carrying electric cables. The bridge was built in sections, the first half being commenced on Dec. 30, 1897, and that part was opened to travel on April 14, 1898. The other half was commenced on April 21, and completed as above.

THE FIRST IRON BRIDGE IN OHIO was erected in 1851, on the Central Ohio Division of the Baltimore & Ohio Railway, over Salt Creek, in Muskingum County. It was a single span Bollman deck truss of 71 ft. Mr. Bollman was at that time Chief Engineer of Construction on the B. & O. Railway. This bridge, after 47 years' service, has just been removed.

A PILE-DRIVING RECORD is reported from Manitowoc, Wis., where Mathews & Keith, contractors of that city, are building a grain elevator for the Northern Grain Co., of Chicago. On June 22, pile-driver No. 5 drove 151 piles in ten hours, and pile-driver No. 4 drove 140 piles in the same time. These piles were from 20 to 24 ft. long, and they were driven from 18 to 20 ft. into the ground to a hardpan stratum. The pile drivers were specially designed by the above firm and have a 5,000-lb. hammer, operated by 30-in. double drums and a 30-HP. engine. Similar drivers were used at Buffalo, N. Y., in putting in the foundations for the Great Northern Steel grain elevator.

THE SINKING OF A STEAMSHIP AT SEA.

Mr. Cecil Lightfoot, of the Lynde British Refrigeration Co., has furnished to several of the English illustrated journals an account of the foundering of the Japanese steamship "Tai Hoku," in the Atlantic Ocean, August, 1897, on her maiden trip to Osaka. The photographic views taken of the sinking of the steamer are the interesting features, and we here reproduce three of them from the "Indian and Eastern Engineer."

The "Tai Hoku" was a steamer of 3,100 tons, built at Middleboro, England, for the Osaka Steam Navigation Co., and she was fitted with a refrigerating plant by the company with which Mr. Lightfoot was connected. Having sailed to Antwerp to complete her cargo, the steamer left that port on Aug. 6, 1897, for Japan. On the following Sunday she passed into a heavy fog bank, off Cape Raso, and at about 9 p. m. the steamer collided violently with another vessel. At first it was supposed that no serious damage had been done; but in half an hour 5 ft. of water was reported in the forehold. The water gained at the rate of about 2 ft. per hour, and the ship gradually settled by the head.

At 4 a. m., on Monday, there were 16 ft. of water in the forehold, and all the pumping power available made no impression upon the inflow. At 5 a. m. all hands took to the boats and pushed off a few hundred yards from the sinking steamer; and at 8.30 a. m. the party was rescued by the steamer "Millfield." By this time the fog had cleared away, and the stern of the "Tai Hoku" could be seen gradually rising in the air. Shortly before 1 p. m. she began to roll heavily and then she plunged and sunk. In the 15 minutes previous to her final disappearance four photographs were taken; of which three are here reproduced.

Fig. 1.—Fifteen Minutes Before Sinking.

Fig. 2.—Five Minutes Before Sinking.

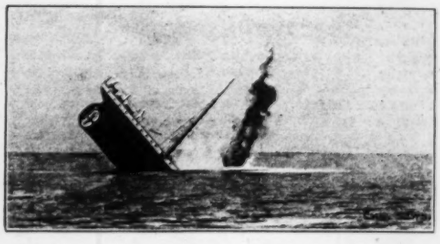


Fig. 3.—The Final Plunge.

THE SINKING OF THE STEAMER "TAI HOKU" OFF CAPE PASO, FRANCE, AUGUST, 1897.

When the "Tai Hoku" went down, there was, of course, considerable steam pressure in her boilers, possibly 60 or 70 lbs. When the bridge collapsed, the siren and fog-horn cords being attached to it, both the siren and fog-horn sounded, just as the vessel disappeared. The third and final view shows, apparently, an explosion. But, as a matter of fact, says Mr. Lightfoot, there is little doubt that when the water reached the boiler flues there was a sudden generation of steam and gas, which rushed with almost an explosive effect up the flues and smoke-stack, carrying with it quantities of soot which remained suspended in the air for some minutes after the ship disappeared. There was not the least sign of the proverbial whirlpool when the ship went down, though there were abundant surface signs of the gradual escape of the air imprisoned in the hull.

THE STEEL DOME FOR THE YERKES OBSERVATORY, LAKE GENEVA, WIS.

(With two-page plate.)

Those of our readers who saw the model of the great Yerkes telescope intended for the University of Chicago, as it stood in the Manufactures' Building, at the World's Columbian Exposition, have doubtless often speculated regarding the future home and work of this remarkable instrument as their eyes have caught from time to time the newspaper reports concerning the progress of work upon the 40-in. objective lens and other parts of the elaborate machinery. The Yerkes telescope, as is quite generally known, is the largest refracting telescope in the world, its object glass being 4 ins. greater in diameter than that of the Lick Observatory telescope at Mt. Hamilton, California, and it is needless to say that astronomers expect much usefulness from it in the particular line of astronomical research to which it is to be applied. Besides being of especial interest to the astronomical world, however, the great refractor is of great interest to the mechanical and structural engineer, for the skill of both has been called into service in designing its ponderous and delicate operating machinery and the building which it is to occupy. From information furnished by the astronomical department of the University of Chicago and by the engineers and contractors who designed and built the observatory dome and its operating machinery, we present here a pretty complete description of the features of particular interest to engineers:

The observatory building, in which the great telescope has been installed, is located at Lake Geneva, Wis., and, like the telescope, was presented to the University of Chicago by Mr. Charles T. Yerkes, of Chicago, Ill. Its general appearance is pretty clearly shown by Fig. 1, which is from a photograph taken before the covering had been placed on the main dome, and before the steelwork of the two smaller domes had been erected. The form of the building, as will be observed, is that of a Latin cross, with the three towers or domes at the extremities. The long axis of the building runs east and west, and is 326 ft. in length. The large dome which contains the 40-in. telescope is at the western extremity and is 90 ft. in diameter. The building is constructed of brown Roman brick with terra cotta ornaments of the same color. The credit of the architectural design is due to Mr. Henry Ives Cobb, of Chicago, Ill., but the general form of the building and its interior arrangements were determined by Prof. Geo. E. Hale, the Director of the Yerkes Observatory.

The chief interest of the observatory from an engineering standpoint lies in the main dome, and its operating machinery, but a brief statement may be made of some of the minor features of construction and equipment. The northeast tower or dome will contain a 12-in. telescope now located at the Kenwood Observatory of the University of Chicago, and is 30 ft. in diameter. The southeast tower is also 30 ft. in diameter and will contain a 16-in. telescope. Between the three towers the space on the two floors of the building will be occupied by a meridian room, a heliostat room, spectroscopic and chemical laboratories, instrument and computing rooms, library, instrument and optical shops, and numerous smaller rooms for different special operations connected with the work of the observatory. A power-house for supplying the necessary power for the various machines is located about 750 ft. from the large dome of the observatory, and is equipped with two 8×10 ins. Ideal engines, each operating a Seimens-Halske dynamo, with a capacity of 200 amperes at 125 volts.

The main tower, in which the 40-in. telescope is located, may, for the purpose of this description, be divided into the revolving dome, the rising floor, the operating machinery and the telescope proper. The circular wall of the tower terminates at a height of 52 ft., and is surmounted by a dome 90 ft. in diameter and 60 ft. high, which revolves on a circular track on the tower walls. Figs. 2 and 3 show a plan and vertical section of the steelwork for the dome. As will be seen the framework is composed of two main girders or arches, standing on each side of the observing slit, and 18 secondary arches, all of lattice girder construction. These main members carry lattice purlins, which act as sway frames, and also jack rafters of channels, which support the sheathing. This sheathing is 1-in. matched pine, covered with tin, the whole idea being, of course, to make the structure as light as possible, since it has to be revolved around to accommodate the telescope.

The principal difficulties in the designing, it will be seen, were, first, that a clear opening, 12 ft. wide, had to be left in the dome from about the horizontal to 6 ft. beyond the vertical, and, second, no ties were possible across the bottom to hold the feet of the arches together. The second of these difficulties was overcome by constructing a heavy circular lattice girder around the rim, to which the feet of the arches were attached. To provide against the first difficulty the strength and rigidity of the main arches had to be depended upon. The opening for the telescope or observing slit, was covered by two shutters, each made up of two curved plate girders, braced together by angle iron bracing and resting on rollers at the top and bottom. These shutters roll each way from the center of the slit to allow for the necessary opening. Besides the regular shutters for covering the opening it was necessary to provide for a light canvas curtain to cover the slit, when the shutters were rolled back, with the exception of what little space was needed for the end of the telescope. This was accomplished by having a track below the girders carry a little carriage on which the canvas curtain rolled.

As previously stated the dome revolves on a circular track, carried by the tower walls. Fig. 4 shows the construction of this track and of the weather guards at the outer edge of the tower wall. As will be seen, the track consists simply of an 85-lb. T-rail resting on a cast-iron girder bolted to the masonry. This girder was laid in sections 7 ft. 3 58-64 ins. long, or eleven sections, each 30° of arc. Twenty-two cast-steel wheels, 36 ins. in diameter carry the dome on the circular track. The journals carrying these wheels are fitted with roller bearings and are so mounted that the wheels are left free to adapt themselves to any possible inequalities of track.

The object of the rising floor was to render the eye-piece of the telescope equally accessible to the observer at all positions of the instrument. Briefly described, this is a circular floor, 75 ft. in diameter, which is so supported and counterbalanced that it can be made to rise and fall vertically through a distance of 23 ft. A balcony around the inner wall of the tower at each extremity of the travel of the floor gives access to it at these points, while at intermediate points of its travel it is entered from two stairways which connect the two balconies. Figs. 3, 5 and 6 show pretty clearly the general construction of the rising floor, and also several details of the dome construction not shown by the previous illustrations. As will be noticed, an opening is left in the rising floor for the standard supporting the telescope. In construction the floor consists of lattice girders, thoroughly braced, and carrying steel joists, which are covered with a wood floor. The total weight of the rising floor is 37.5 tons.

The machinery for rotating the dome and operating the rising floor is located in the basement, and consists of both hand and power machinery for each duty. To rotate the dome an endless wire cable passes around an angle fastened to the inside of the dome at the bottom. This cable coming from opposite directions passes over two vertical idlers, thence down and around a vertical

operating sheave, thence around a tension pulley. The operating sheave is geared with an electric motor or with a hand operating device, as may be desired. An endless hand rope also runs from the sheave in the basement to one on the upper balcony, which allows the dome to be turned from either balcony or any intermediate point between them. The method of operation, it will be seen, is quite simple; the wire cable runs entirely around the dome horizontally, as if it were a large drum, and is held taut by the tension weight, while the operating sheaves give it the required motion. To raise and lower the rising floor four rope drums are placed, as shown by Fig. 7, and operated by worm gears on shafts radiating from a central motor. These drums are place 90° apart, where the columns, which guide the counterweights, are also placed. At each column is a wire cable which is attached to the top of the floor and thence passes to and over a sheave, and has its opposite end fastened to the counterweight. From the bottom of the counterweight another cable passes to and around the drum in the basement and thence to an attachment on the bottom of the floor. The floor and counterweight thus form links in an endless cable, whose movement is controlled by the operating drum.

From the foregoing the construction and operation of the 90-ft. dome will be pretty clear. As will be imagined, the erection of the various parts required great care and skill, particularly as the height of the top of the dome from the ground was 115 ft., and as severe storms arise with great suddenness in this region. The framework being mounted on wheels and also being very light, the effect of a sudden heavy wind storm upon the partly connected members was very likely to be disastrous. No accident with the dome proper occurred, however, with the method adopted, which is illustrated in the accompanying cuts.

A derrick was first erected on the brick foundation for the telescope, which was at the center of the tower. The mast of this derrick was about 50 ft. high and the boom 110 ft. long, or long enough to cover the top of the circular tower wall with ease. With this derrick the circular track and the greater part of the dome framing was placed. The first thing done was to erect the two main arches. These being too large to be raised entire inside the tower, the middle section, 35 ft. long, of each was first raised and then the two end sections were raised and connected with it. The feet of the arch were then sprung out to their positions on the circular track. Fig. 8 shows the main arches erected and one-half each of three of the smaller arches connected with them. All the smaller arches were assembled on the ground inside the building, and the halves raised complete with the wheels attached, Fig. 9. The purlins, horizontal girder and bracing between the arches were connected as fast as the arches were placed, Fig. 10 shows the dome framework practically complete, and the shutters in the process of erection. Following the completion of the dome, the standard carrying the telescope was erected, and, finally, the telescope, tube, rising floor, and minor structures put in place. This completed the main structural work of the dome and tower.

It will not be out of place in connection with the foregoing to say a few words regarding the great telescope for which the structures described have been constructed, and through the courtesy of Prof. Geo. E. Hale, Director of the Yerkes Observatory, we have been furnished with the following description:

Representing as it does an increase in aperture of but 4 ins. over the largest equatorial refractor hitherto constructed, the Yerkes telescope might not at first sight be supposed to offer any special difficulties of construction or design. As a matter of fact, however, the problem of designing a suitable mounting for the 40-in. objective was by no means a simple one. The great weight of the objective, about 1,000 lbs. in its cell, and the desirability of attaching an equally heavy spectroscope at the eye-end made necessary the construction of a tube of exceptional rigidity. The consequent great weight of the moving parts must inevitably increase the difficulty of moving the telescope, and for this and other reasons it was decided to provide a complete system of electric motors and clamps, for the purpose of effecting the various operations usually performed by hand. It will thus be seen that the greatest experience and skill would be required of the designer of a really successful mounting.

After carefully examining most of the great telescopes in American and European observatories, the writer decided to recommend to Mr. Yerkes that the contract for the mounting be awarded to Messrs. Warner & Swasey, not only because of the well-known excellence of their workmanship, but more especially on account of the invaluable experience gained by this firm in designing and constructing the mounting of the 36-in. Lick refractor.

The cast-iron column consists of four sections, tapering from 11 × 5 ft. at the base to 10 × 5 ft. at the junction with the head. These four sections are bolted together, and rest on a cast-iron foot which is firmly anchored to a massive brick pier supported on a concrete foundation 32 × 28 × 5 ft. At the top of the column is the equatorial head, which is cast in a single piece. The column and head rise to a height of 43 ft. above the lowest position of the rising floor, and weigh 50 tons. Surrounding the head is an iron balcony, accessible from the rising floor by means of a spiral stairway on the south side of the column, which also leads to the clock room in the upper section of the head.

The polar and declination axes are of hard forged steel, and weigh 3½ and 1½ tons respectively. The polar axis, 13½ ft. long, has a diameter of 15 ins. at the upper bearing and 12 ins. at the lower bearing. At both of these points the friction is relieved by means of live rings of steel rolls, running in steel yokes, and held against the axis by spring levers. The lower end of the axis rests on a double set of 40 hardened steel balls, 1 in. in diameter. The upper end carries the main driving gear, which has 330 teeth, is 8 ft. in diameter, and weighs one ton. This is driven by a worm geared to the driving clock, and when clamped to the axis sets in motion a mass weighing 20 tons.

The declination axis which runs in Babbitt bearings in the declination sleeve is 12 ins. in diameter and 11½ ft. long. The pressure of this axis upon its bearings, amounting, with the weight of the tube, to about 8 tons, is relieved by a live ring of steel rolls, which greatly reduces the friction.

The tube is made of sheet steel, varying in thickness from 7-32-in. at the center to ⅛-in. at the ends. Its diameter is 52 ins. at the center, 42 ins. at the objective end and 38 ins. at the eye end. It is 60 ft. long, and weighs 6 tons. For the central station, to which the declination axis is bolted, it was considered necessary to use some material more reliable than cast-iron, which is ordinarily employed in smaller mountings. The heavy sheet steel selected for this purpose seems to be in all respects satisfactory.

The driving clock stands in the clock room in the upper section of the column, where it is easily reached from the spiral stairway. The double conical pendulum, mounted isochronously, makes sixty revolutions per minute. It is provided with a simple electric control. An electric motor automatically winds the clock when the driving weight has reached a point near the limit of its run.

The telescope is so designed that it would be in perfect balance with the spectroscope weighing about ½ ton attached to the eye end. When the spectroscope is removed iron weights are clamped to the tube near the eye end in order to restore the balance.

The clamps and slow motion can be operated by the observer at the eye end, where the fine declination circle can also be read. An assistant on the balcony can move the telescope in both right ascension and declination, and read the fine hour circle. The divisions of the coarse circles are visible from the floor.

In addition to the ordinary appliances just referred to for actuating the quick and slow motions and clamping the telescope, a complete system of electric motions, clamps and illumination is also provided. Conveniently placed switches at the eye end and on the equatorial head, enable the observer or his assistant on the balcony to start or stop the slow motion motors, and to clamp or unclamp in right ascension and declination by simply pressing knobs. The quick motion motors are controlled from the balcony by switches, and from the eye end by cords. The circles are illuminated by incandescent lamps, connected with switches at the eye end and on the head. Provision is also made for electric illumination of the micrometer wires.

The 40-in. objective of the Yerkes telescope was made by the firm of Alvin Clark & Sons, Cambridgeport, Mass., from disks furnished by Mantois of Paris. The crown lens is about 2½ ins. thick at the center and ¾-in. at the edge; it weighs 200 lbs. The flint lens, which is separated from the crown by a distance of 8⅝ ins., is about 1½ ins. thick at the center, 2 ins. thick at the edge, and weighs over 300 lbs. The lenses are mounted upon aluminum bearings in cast-iron cell.

The structural work for the dome and rising floor was designed by the King Bridge Co., Cleveland, O., Mr. W. P. Brown, Assoc. M. Am. Soc. C. E., Engineer, under the direction of Warner & Swasey, of Cleveland, O, who had the contract for the dome as well as for the telescope. The erection was done by R. S. Write & Co., of Pittsburg, Pa. We are indebted to these various firms and to Prof. Geo. E. Hale, of Yerkes Observatory, for the information from which this description has been prepared.

NOTES FROM RECENT WATER-WORKS REPORTS.

Unusual precautions to secure water tightness were taken in the construction of the larger Wachuset aqueduct of the Metropolitan water system where it is laid on the Assabet bridge. This bridge is of masonry, 359 ft. long, with 30 ft. of masonry aqueduct not on the bridge. The interior lining of the aqueduct is of 8 ins. of brick. A continuous lining of sheet lead was placed back of the brick. The sheets were 16 ft. long, 9 ft. wide, and weighed 5 lbs. per sq. ft. They were burned together without the use of solder. Before placing the lead the bottom and sides of the aqueduct against which it was to be placed were smoothly plastered, and then painted with asphalt. After the lead sheets were in place they were covered with a thick layer of asphalt. The top of the whole bridge was covered with granolithic material laid on two thicknesses of roofing felt, covered with coal tar. This was done to prevent the rain from soaking into the masonry, as well as to give the bridge a suitable finish. Various other features of the work of the board have been described in these columns from time to time. The report of the board for 1897 is a very interesting document. Mr. F. P. Stearns, M. Am. Soc. C. E., of Boston, Mass., is Chief Engineer of the work, and Mr. Thos. F. Richardson is Engineer of the Dam and Aqueduct Department, under which head comes the job described above.

The entire flooded area of the new Hobbs Brook storage and settling reservoir of the water-works of Cambridge, Mass., was cleared of all muck and other soil containing organic matter until sand, gravel or boulders were reached. The basin has an area of 653 acres and a storage capacity of 1,500,000,000 gallons. About 300 acres of land surrounding the water surface was bought by the city for the sanitary protection of the water. A large amount of riprapping of artificial slopes of the basin was done in order to prevent the growth of vegetation and erosion of the banks by waves, each of which might prove deleterious to the stored water. The riprapping, to the close of 1897, had cost about $125,000. The cost of removing the soil, mentioned above, is not stated, but it must have been large. This work is one of the most notable instances of water supply protection that has yet arisen in this or any other country. Practically nothing of the sort has been done outside of New England, and most of this work there has been confined to Massachusetts, and in that state to Boston and its vicinity. Mr. Edwin C. Brooks is Acting Superintendent of the Cambridge water-works.

A wrought-iron water tank, 65 ft. in diameter, 55 ft. high, and having a capacity of 1,365,000 gallons, was built at Fall River, Mass., in 1897. The bottom of the tank is made of ½-in. plates. The side plates are from 11-16 to 5-16-in. thick. Angle irons ½-in. thick are placed at the top and bottom. The bottom angle is 5×5 ins., on the outside, double-riveted to the bottom and sides. The top angle is 5 × 5 ins., with the horizontal member down. Although the water consumption at Fall River in 1897 was only 36.29 gallons per inhabitant, or 37.64 per consumer, Mr. Patrick Kieran, Superintendent of the water-works, shows by tables and diagrams that 40% of the pumpage can be accounted for only by leakage from the mains or else by leakage and waste through unmetered services. Of 6,422 services, 5,954 are metered. The water unaccounted for is heaviest in the winter months, indicating that unmetered consumers let the water waste to prevent their pipes from freezing. Mr. Kieran advises that meters be placed in a number of places where the premises are connected with the sewers.

The new Hawkes Brook storage reservoir of the water-works of Lynn, Mass., yielded good water when first drawn from, contrary to the experience with many new reservoirs. This is attributed by Mr. John C. Haskell, Superintendent of the water-works, to the stripping of the site of all organic matter down to "the level at which water can

waste from the pond," and covering the remainder of the flooded portion "with about 1 ft. of gravel and sand." The reservoir has an area of 75 acres and a capacity of 300,000,000 gallons. The extra work just described cost about $23,000. In 1894-5-6 much soil was removed from the bottom of Walden pond and the swamps in the drainage area were drained. In 1897 the water from this source was much better than in previous years, when it had had a disagreeable taste and odor.

Two heavy rainfalls occurred at New Bedford, Mass., in 1897, as recorded by Mr. Thos. Rodman, and given in the last report of Mr. R. C. P. Coggeshall, Superintendent of the water-works. On Aug. 16, there was a thunderstorm, during which 3.57 ins. of rain fell in three hours, or 1.19 ins. per hour. Sewers were overtaxed and much damage was done. During a 36-hour storm, beginning on Nov. 1, there fell 5.67 ins. of rain, of which 5 ins. fell in 20 hours. From May 1 to Sept. 1 the total rainfall was 22.69 ins.

Algae growths in the Ludlow reservoir of the water-works of Springfield, Mass., continue to give trouble, as they have to a greater or less extent ever since the reservoir was constructed, now many years ago. The last report of the water commissioners states that by emptying the reservoir five years ago the water from it was greatly improved for two years, but towards the end of the season of 1894, algae again became abundant, while in 1897 the water was rendered unfit for use. The rainfall was so abundant last season that this did not matter much, but the board says the storage will be more necessary in the future, so that "something will soon have to be done to purify this large body of water." The capacity of this reservoir, according to "The Manual of American Water-Works" for 1897, is 2,000,000,000 gallons. Mr. J. C. Hancock is superintendent of these works.

The approximate cost of laying ordinary water pipes at Providence, R. I., with all appurtenances except hydrants, and including iron at $30 per long ton, is given in the last report of Mr. Otis F. Clapp, City Engineer of Providence, as follows:

Size, ins.	Cost, per lin ft.	Size, ins.	Cost, per lin. ft.
4	$0.498	16	$2.403
6	.725	20	3.359
8	.973	24	4.454
10	1.244	30	6.348
12	1.593	36	8.540

Mr. Edmund B. Weston, M. Am. Soc. C. E., is the Assistant Engineer in Charge of the water department.

A special report on "The Relation of the Water Supply, of Elmira, N. Y., to the Typhoid Fever Epidemic of 1896," has recently been published by the Board of Health of that city. The report was made by Prof. Olin H. Landreth, M. Am. Soc. C. E., of Schenectady, N. Y., Consulting Engineer to the New York State Board of Health, and the conclusions drawn were noted in these columns shortly afterward. The water company has since installed a mechanical filtration plant.

The total amount of water pumped at Poughkeepsie, N. Y., was less in 1897 than in 1886, notwithstanding the fact that the number of taps has increased from 1,699 to 2,947 in the last eleven years. This consumption per tap averaged only 572 gallons a day in 1897, against 1,003 gallons in 1886. These figures are doubtless to be accounted for by the fact that of the 1,699 taps in use in 1886, only 433, or less than one-fourth, were metered, while in 1897 over three-fourths of the taps, or 2,244 out of 2,947, were metered. It should also be noted that the water supply of Poughkeepsie has been filtered through these and previous years, and that the filters have long been operated at least to their full capacity. Had the total consumption been allowed to increase as in many other cities, the duplication of the filter plant, recently effected, would have been imperative long ago. The population of Poughkeepsie in 1890 was 22,000, and the average daily consumption in 1897 was 1,688,298 gallons. Mr. Chas. E. Fowler is, and has been for many years, superintendent of the water-works at Poughkeepsie.

Only some 20 to 30 of the 4,187 service pipes connected with the water-works of Yonkers, N. Y., were unmetered at the close of 1897. The estimated population of the city was 42,000, of which it is estimated that 35,000 were on streets provided with water and 34,000 were actually supplied. The average daily consumption, stated in a variety of ways, was as follows: Total, 3,588,307 gallons; per inhabitant, 83; per consumer, 102; per tap, 857; per domestic meter, 174; per manufacturing meter, 7,396 gallons. About 20% of the total consumption passed through the 4,031 domestic meters. Mr. A. W. Kingsbury is now acting clerk of the works, Mr. Jos. Lockwood, for many years superintendent, and lately clerk in addition, having died last August.

The benefits of the meter system are still further illustrated by the last report of Mr. W. C. Hawley, Assoc. M. Am. Soc. C. E., Superintendent at Atlantic City, N. J. The cost of coal used at the pumping stations has been greatly reduced through the reduction in consumption; and enlargements to the plant estimated to cost $250,000 have been indefinitely postponed. Tin-lined galvanized iron has been used with satisfaction for service pipes. Mr. Hawley states that it costs less than the tin-lined lead pipe, and is believed to be as durable. The commissioners of these works state that a reduction in the meter rate from 18 and 14 to 12 cts. per 1,000 gallons has been made possible by raising $12,100 by general taxation, thus placing the burden of fire protection and water used for other public purposes where it belongs, upon the property benefited. The commissioners recommend that the minimum meter rate vary with the amount that would be charged for water at fixture rates.

A special report on filtration has been published by the water commissioners of Reading. Slow sand filtration is recommended, as previously noted in this journal. The pamphlet contains reports by Mr. Emil Nuebling, Superintendent and Engineer of the works, and Mr. Allen Hazen, Assoc. M. Am. Soc. C. E., Consulting Engineer, 220 Broadway, New York city, and copies of reports for the city of Philadelphia, by Prof. E. G. Smith, Madison, Wis., Prof. Wm. P. Mason, Troy, N. Y., and Mr. Rudolph Hering, M. Am. Soc. C. E., New York city. During the investigation preceding the reports, experimental filters were operated for a number of months, including ordinary filter beds and beds built on the plan of the Pennsylvania Sanitation Co., of Philadelphia. Numerous analyses of applied water and effluent are given in the report.

The Great Falls dam across the Potomac River, at Washington, D. C., was raised 2½ ft. in height for a distance of 2,095 ft. in the years 1895 and 1896. As a strong current of water, giving a head of from 3 to 5 ft. on the upstream side, flows over the dam, and as the river carries much driftwood at times, it was decided to use cofferdams, enclosing as much of the dam as the workmen could raise in a single day. Two wooden bulkheads, each 30 ft. long, were placed at the upper face of the dam, inclining upstream and held in place by the pressure of water above, resisted by 1½-in. iron bolts sunk into the old masonry. The bulkheads were composed of five 2 × 12-in. Georgia pine planks, placed edge to edge, fastened together longitudinally by five 2 × 12-in. cleats, 40d. nails being used.

Sand bags were used for end dams. The average width of the masonry was about 8 ft. The work was done by contract in 176 working days, 84 working days being lost by high water, and 23 by lack of stone. The total cost of the cofferdams, including furnishing, setting and calking, was $2,064, or 98½ cts. per lin. ft. The total cost of raising the dam 2½ ft. for a distance of 2,095 ft. was $86,373, including $10,245 for a suspension cableway furnished by Mr. R. H. Hood, of Washington, D. C. The work was carried out under the direction of Capt. D. D. Gaillard, Corps of Engineers, U. S. A., in Charge of the Washington Aqueduct, and is described, with illustrations, in Appendix AAA. of the Annual Report of the Chief of Engineers for 1897.

The above report, which doubtless may be obtained by addressing Captain Gaillard, contains an interesting account of measurements of the flow through the old Washington Aqueduct. In this work the velocity was obtained by using a Buff & Berger current meter, provided with an electric register. Readings were taken through manholes, an index frame marked to correspond to 33 different points in the cross-section of the aqueduct being employed in taking the readings. The readings recorded were the average of two readings at each point, the second set in inverse order. The cross-section of the aqueduct was divided into 16 areas, "and the volume of flow per second through each of these areas was computed. The mean velocity was then computed by dividing the sum of these volumes by the total area of the conduit section." The carrying capacity of the conduit at low water in the Potomac was found to be about 75,000,000 gallons per day. The report contains a discussion of some of the hydraulic problems involved which might be of interest to those having large aqueducts in their charge, although the local conditions at Washington are in some respects exceptional.

Crude oil was used for fuel by the Detroit water-works for several years, but was discontinued in 1896, after the price had been raised from 1.55 to 2.8 cts. per gallon. For the year 1895, with crude oil at 1.55 cts. per gallon, the cost of fuel was $2.18 per 1,000,000 gallons. In 1897, using semi-bituminous coal costing from $2.40 to $2.60 a ton, the cost of fuel was $1.40 per 1,000,000 gallons, and the pressure had been increased 4½% meanwhile. The Detroit works continue to show the beneficial results of waste prevention, the total pumpage for 1897 being less than it was in 1887, although the number of families supplied has increased from 34,486 to 54,945. There seems to be plenty of room for further improvement, as the daily consumption in 1897 is given as 125 gallons per capita. The already low water rates were cut in half during 1897, and it estimated that the average amount paid by each family for water in 1898 will be only $4.02. Mr. L. N. Case is general superintendent of the works, and Mr. Gardner S. Williams is civil engineer. During the year Mr. Williams has made studies, by means of temperature observations and otherwise, of the possible pollution of the supply at the intakes from shore currents. The temperature studies were based on the fact that the shore currents would be warmer than the others.

The report of Mr. F. E. Herdman, Chairman of the Water Committee of Winnetka, Ill., is a good example of the value of an engineer as a member of a water board. Winnetka is a small suburb of Chicago, which built works in 1893. In his report Mr. Herdman presents a careful analytical study of the financial operations of the works, and shows how economies might be introduced by improvements in the plant. His report is a strong contrast with those of most small and many large works, and shows the value of accurate scientific records. Comparatively few works, if we can judge from the annual reports received, have their records kept in a way designed to throw the proper light on the economy of the operation of the different parts of the plant. Judging from the experience at Detroit, cited above, Mr. Herdman's allowance of 1.7 cts. per gallon as the price at which crude oil could be bought as fuel is too low, unless freight rates and other conditions would be more favorable in the vicinity of Chicago than at Detroit. The latter city paid only 1.5 cts. per gallon for oil at the start, but the price was advanced slightly soon afterwards, and finally, by a sudden raise, was fixed at 2.18 cts.

The last report of Mr. F. W. Cappelen, City Engineer of Minneapolis, contains descriptions of improvements to the water-works system, including a double line of 50-in. steel force and distributing mains 16,676 ft. long, 890 ft. of single 50-in. steel pipe, and 15,758 ft. of single 16-in. cast-iron drain pipe, apparently in the same trench as the steel pipe. The pipe line included a submerged river crossing about 750 ft. in length. The contract for

this work, with all appurtenances, was let to the T. A. Gillespie Co., of Pittsburg, Pa., for $343,726. Winston Bros., of Minneapolis, bid $477,500 for the job, using cast-iron throughout.

The coating for the steel pipe was mineral rubber asphalt from Utah, manufactured by the Assyrian Asphalt Co., of Chicago, the pipe being dipped vertically in a bath at a temperature of 300° F. This coating, or some other equally good,

VIEW UNDERNEATH APPROACH TO THAMES RIVER BRIDGE, LONDON, ONT., SHOWING STEEL PIPE SEWER.

A. O. Graydon, City Engineer; Willis Chipman, Consulting Engineer; E. Leonard & Sons, London, and Central Bridge & Engineering Co., Peterboro, Contractors.

was named in the specifications, the final determination to be made by the city engineer. Mr. Cappelen tested this coating, together with Trinidad asphalt, mixed with dead oil, used by the Hugo Iron Works, of Duluth, Minn., on the new 42-in. steel pipe in that city; California asphalt from Waldorf, Cal., and the same mixed with about 40% of maltha; and finally a coating from Dennis, Long & Co., of Louisville, Ky. The details of these tests and analyses of the mineral rubber, Trinidad and combined California asphalt and maltha coatings, which three were considered the best of the five, are given in the report. Regarding the mineral rubber coating, Mr. Cappelen says:

> Coating covered the pipe splendidly in all cases and somewhat thicker for the 300° (against 400°) temperature and stood hammer test perfectly. The material is so elastic that by cutting into the coating and entirely removing some of it, the opening can be covered by simply hammering the edges around the space so that it is impossible to see the joint. The coating did not foam even up to 700° F.
>
> The mineral rubber coating (on special plates.—Ed.) was not affected by muriatic acid (H C L) nitric acid (H N O_3) nor by sulphuric acid H_2 S O_4.

The cost per ton of the mineral rubber coating is given as about $60; for the Trinidad, $45; and for the California and maltha, $40. The contract for this pipe line was executed on June 22, the award having been made on June 18, and the contract time for doing the work being five months, with a bonus and penalty clause of $250 per day. Ground was broken July 18, the first pipe was laid July 29, and the work completed Nov. 9, the contractors thus earning a bonus of $2,250. A force of 500 men, two steam shovels, for trenching and back-filling, respectively, two air compressors and one pumping outfit were employed. On Aug. 24 there were laid 1,120 ft. of 50-in. steel pipe, which Mr. Cappelen says "is a record unequalled anywhere."

The report contains a "Chart Showing Relations Between Rainfall, Sanitary Improvements and Typhoid Fever in Minneapolis, Minn., from 1870 to 1897." The chart shows that while sanitary improvements have lowered the typhoid death rate very materially, there is still opportunity for much further improvement, there having been 70 deaths per 100,000 from typhoid in 1897. Filtration of the whole water supply is a part of the scheme of improvements adopted some time ago.

To encourage the use of meters at St. Paul, they are furnished by the water department without charge to the consumer, and also set free of charge. We have already expressed our opinion on this subject to the effect that meters should be considered as a part of the water-works plant and charged to construction. Of course there may be exceptions to this, as well as any other detail of water-works practice. In some cases the financial condition of the works, or the powers granted to the water department, will not allow the practice, but generally these difficulties might be surmounted if the resulting advantages were half appreciated. Mr. John Caulfield is secretary of the St. Paul works.

CARRYING A STEEL PIPE SEWER ACROSS A BRIDGE AT LONDON, ONTARIO.

In the construction of the intercepting sewers for London, Ontario, it was necessary to carry a 36-in. main sewer across the River Thames at an elevation of 24 ft. above low water. The portion of the sewer exposed is about 630 ft. long, and it **was thought advisable to construct a steel truss bridge, of 162 ft. span, with viaduct approaches of 468 ft. to carry a 16-ft. roadway and 4-ft. walk, and supporting beneath the floor a 36-in. steel pipe for the sewage flow. The floor beams throughout were spaced 18 ft. apart, and their construction is clearly shown on the cut herewith.**

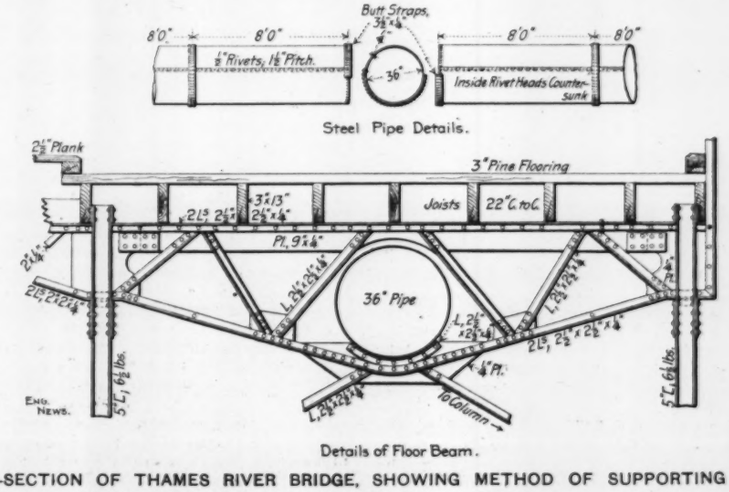
The sewer pipe was built of ¼-in. plates, 8 ft. long, lap-jointed longitudinally and butt-jointed transversely. Below the horizontal diameter all rivet holes were countersunk, thus leaving the bottom half perfectly free from obstructions. The pipes were given two coats of pure graphite paint (inside and outside), over one coat of red lead. They were put together in the shop in 32-ft. lengths, and, to facilitate jointing in the field, the butt-strips on their ends were made in halves (upper and lower alternately). No difficulty was found in putting them in position, as much as 200 ft. being erected in one day under the viaduct. There are three curves in the pipe line and these were made to conform to a central radius of 74 ft.—the center of each seam coming on the arc of the circle.

The piers and pedestals (for columns) were made of concrete throughout, with four stone bridge-seats. The main body of the work was composed of concrete of the following proportions: Six parts of crushed stone, two parts sand, one part crusher screenings, one part Portland cement. The whole of the exposed surfaces were faced with 3 ins. of 2 to 1 mortar deposited at the same time as the rest of the work, and pressed firmly against the molds.

The concrete was laid in layers of from 9 to 12 ins. and gently rammed, not more than 3 ft. in depth being laid in any one day. On removing the molds the main piers were washed over with three coats of cement wash. The tops of the piers and pedestals are finished with 6 ins. of a concrete made of one part of cement, one part of sand and three parts of crusher screenings. A stonemason having to cut out some of this concrete a month later, said "it was harder cutting than limestone."

The molds used were of smooth 2-in. planks made in 4-ft. frames, held in position by iron rods passing through the piers, and so arranged that small bolts with hooks at their ends could be easily drawn out when the molds were to be removed. The west river pier was laid on a 10-in. timber foundation, resting on piles spaced 2 ft. 6 ins. on centers, while for the east pier hard clay was found at about 6 ft. below the river level. About 425 cu. yds. of concrete were laid. Canadian Portland cement was used throughout, giving high tensile tests and being very finely ground. Not more than 5% residue was left on a 2 sieve of 100 meshes per inch.

The work was designed and carried on under the direction of Mr. A. O. Graydon, City Engineer, and Mr. Willis Chipman was Consulting Engineer for the sewer system. The steel pipe was built by E. Leonard & Sons, of London, and the Central Bridge & Engineering Co., of Peterboro, built the bridge and erected the pipe. The cost of the work was about $12,750. We are indebted to Mr. W. T. Ashbridge, Assistant Engineer, in charge of sewers, for the material from which our illustrations and description are prepared.



CROSS-SECTION OF THAMES RIVER BRIDGE, SHOWING METHOD OF SUPPORTING STEEL PIPE.

TRACK ELEVATION AND DEPRESSION AT THE 16TH ST. CROSSING, CHICAGO.

One of the most extensive and complicated systems of railway tracks in the world is that which occupies the district along the Chicago River, from 14th St. to 22d St., which district contains the freight and terminal yards of a number of railways, and through which run a multitude of main tracks, crossing and connecting in a most bewildering manner. In fact, if a person undertakes to walk across this district he finds it somewhat difficult to keep his bearings. On the large proportion of this district, which is devoted exclusively to railway purposes, there is little need of track elevation, and safety to the train service entering and leaving the district is ensured by a complete interlocking switch and signal plant established at the outlet at Stewart Ave. and 21st St. This plant was described and illustrated in our issues of Sept. 22, 1892, and Nov. 16, 1893, and in the latter issue we published a map of the tracks throughout this entire district.

At the eastern side of the district, however, the tracks cross and encroach upon streets having considerable traffic. Reference to the map above mentioned will show a very complicated network of tracks in that part of the district bounded by Dearborn St., 15th St., 16th St., and the Chicago River, and this is the worst part of the whole system, as there is a constant traffic of trains and switching movements, interfering with and endangering the street traffic. It is this section of the district which is dealt with in the present article. The interlocking plant above mentioned does not protect any tracks or crossings north or east of 18th St., and the railway crossings of this section were protected only by flagmen, while the Clark St. crossing was protected by gates.

This particular section, known as the 16th St. crossing, is probably the most complicated system of grade crossings in Chicago. It comprises a network of connecting and intersecting tracks, over which there is a continual traffic, including main line and suburban passenger trains, freight trains, light engines, and freight and passenger switching movements, to say nothing of the constant service of electric cars on Clark St. There is a daily movement of 5,000 cars and 500 engines, and the passage of this crossing was often enough to try the nerves of the street car passengers, who beheld engines and trains apparently moving upon them from all directions.

At this point the parallel tracks of the Chicago, Rock Island & Pacific Ry. and the Lake Shore & Michigan Southern Ry., running south from the Van Buren St. terminal station, and close to the west side of Clark St., are crossed diagonally by the tracks of the Atchison, Topeka & Santa Fe Ry. and the Chicago & Western Indiana R. R., which start from the Polk St. passenger terminal station and the various freight yards east of Clark St. Just beyond, the roads first mentioned are crossed at right angles by the tracks of the Chicago, Madison & Northern Ry. and the St. Charles Air Line (Illinois Central R. R.), which connect with the Illinois Central R. R. main line tracks on the lake front. These are not merely crossings, but every line is connected with every other line and with numerous freight tracks in order to provide for the interchange of cars between the various roads. Some idea of the traffic may be gathered when it is explained that, in addition to the roads named, the trains of the New York, Chicago & St. Louis Ry. now run into the Van Buren St. terminal station, and that the Chicago & Western Indiana R. R. is a terminal road used by no less than seven railways (the Atchison, Topeka & Santa Fe Ry., Chicago & Eastern Illinois R. R., Grand Trunk Ry., Chicago, Indianapolis & Louisville Ry., Erie R. R. and Wabash R. R.).

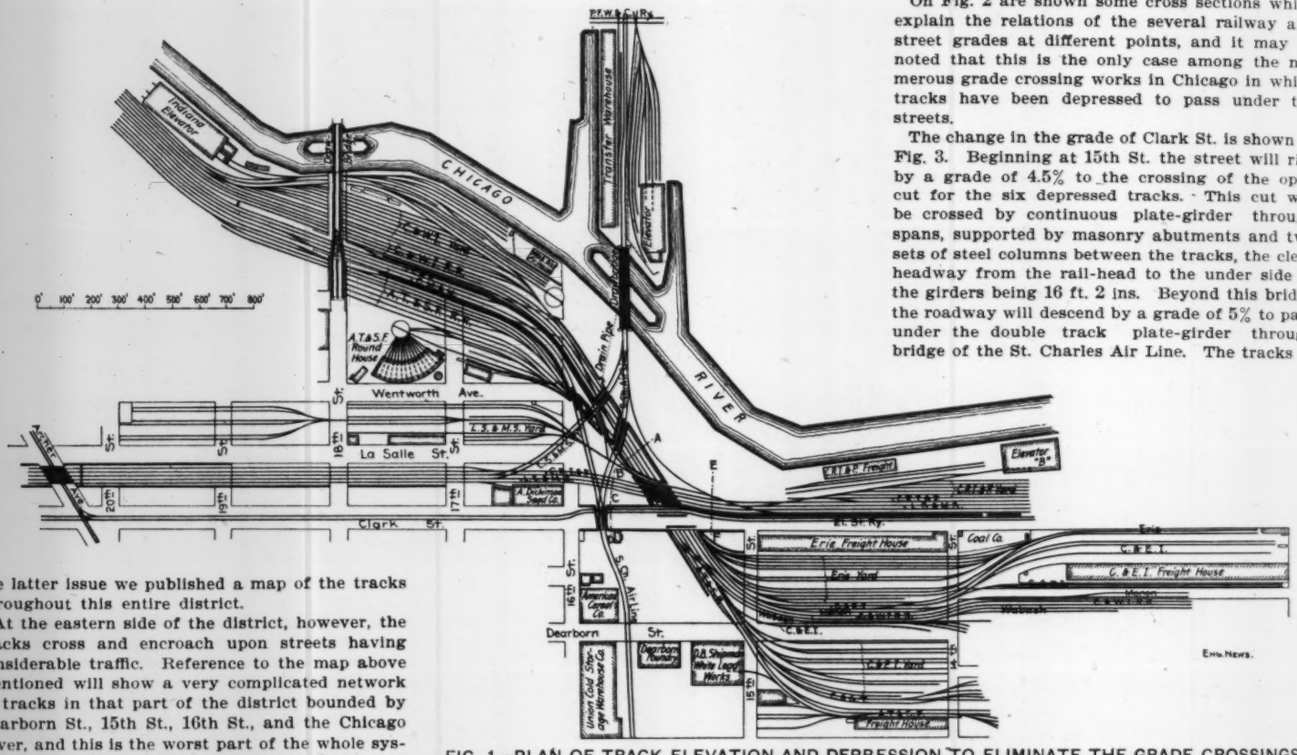
When the city of Chicago undertook in earnest the elimination of the numerous grade crossings of the streets by compelling the railways to elevate their tracks, this crossing came up for consideration, but the difficulties of preparing a satisfactory plan which would be accepted by the city and by all the railways interested were so great that the matter has been laid aside from time to time until the present year, when, by agreement, the entire work was put into the hands of Mr. James Dun, M. Am. Soc. C. E., Chief Engineer of the Atchison, Topeka & Santa Fe Ry. The difficulties arose largely from the fact that it was desired, in making the change, to separate the grades of the different railways, and thus, as far as possible, eliminate track crossings as well as highway crossings at grade. Considering that the tracks had still to be connected by switches and turnouts, it will be seen that the problem to be solved was difficult and complicated. The plans were finally agreed upon, however, by all parties concerned. Work was commenced on April 24, and is to be completed this season. Major G. W. Vaughn, M. Am. Soc. C. E., is the Engineer in Charge.

The accompanying plan, Fig. 1, shows the arrangement of tracks as it will be when the work is completed. The four tracks of the C., R. I. & P. Ry. and the L. S. & M. S. Ry. (running north and south), will be elevated about 12 ft., as a continuation of their track elevation which now extends north from Englewood to 16th St. (Eng News, March 17.) The six diagonal tracks (two for the A., T. & S. F. Ry. and four for the C. & W. I. R. R., and the lines using it), will be depressed about 9 ft., passing under the elevated lines and under Clark St. in an open cut with vertical concrete retaining walls. The St. Charles Air Line and C., M. & N. Ry. will be elevated, so that there will still be one railway crossing at grade, a double track line crossing four tracks at right angles. The arrangement makes it necessary to change the grade of Clark St., which will be raised to pass over the depressed tracks and then inclined downward to pass under the elevated tracks of the St. Charles Air Line. The elevation of this latter line has made it necessary to raise the grade of the South Side Elevated R. R., which crosses it just east of State St.

On Fig. 2 are shown some cross sections which explain the relations of the several railway and street grades at different points, and it may be noted that this is the only case among the numerous grade crossing works in Chicago in which tracks have been depressed to pass under the streets.

The change in the grade of Clark St. is shown in Fig. 3. Beginning at 15th St. the street will rise by a grade of 4.5% to the crossing of the open cut for the six depressed tracks. This cut will be crossed by continuous plate-girder through spans, supported by masonry abutments and two sets of steel columns between the tracks, the clear headway from the rail-head to the under side of the girders being 16 ft. 2 ins. Beyond this bridge the roadway will descend by a grade of 5% to pass under the double track plate-girder through bridge of the St. Charles Air Line. The tracks of the Clark St. electric line, however, will descend on a somewhat steeper grade. These tracks will be at one side of the street, as shown in Figs. 1 and 2, and the portion of the roadway which they occupy, 26 ft. in width, will be separated from that used for street traffic, 42 ft. wide, by a dwarf wall and iron fence. Under the Air Line railway bridge the clear headway will be 12 ft. for the roadway and 13 ft. 6 ins. for the electric railway. South of this bridge the grades of the roadway and the car tracks will rise, approaching each other until they coincide at the point where they meet the present grade of the street, just north of 16th St. The new grade of the street will be about 10 ft. above the present grade at the depressed tracks, and about 1.6 ft. below it at the bridge under the St. Charles Air Line.

The retaining walls are all of concrete, and present a very good appearance, while the great advantage of this material is its low cost and the rapidity with which the walls can be built. The foundations are in a good stiff clay, the engineers having been agreeably disappointed in not finding the soft spots or pockets which had been expected. The concrete is mixed by machinery in a work train consisting of cars loaded with cement, sand and broken stone, a flat car at the head of the



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train being equipped with an engine and boiler to drive the mechanical mixer. When the train is in place on the side track, planks are nailed upon the cars, along which the materials are carried in wheelbarrows to the mixing plant. The concrete is made very wet, is carried to the site in iron wheelbarrows, and is kept well rammed. Two of these mixing plants are in use, being operated by the Brownell Improvement Co., which has the contract for the concrete work, which work is to be finished by August.

The incidental work includes the laying of new gas mains across the site, and the laying of pipes to drain the open cut for the depressed tracks. For this latter purpose 12-in. pipes will lead to three 24-in. pipes discharging into the river. To prevent flooding by high water in the river, there will be a pump house, with stop wall and gates built just behind the retaining wall. The gates will be closed by the back pressure from high water in the river, and a centrifugal pump will then lift the drainage water from a well or sump and discharge it into the river. During construction there is a continual rearrangement of the tracks. There are still in use 35 grade crossings within a radius of 150 ft., and the handling of trains over these various crossings is effected by a system of watchmen and flagmen who are very expert in keeping the traffic moving without confusion or accident. During the work a part of Clark St. has been closed to traffic and the electric cars have been diverted to another route.

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It is estimated that the work will cost about $400,000, but the apportionment of cost between the several railway companies interested can only be determined after the work is done, as previous to that time the monthly apportionments will vary as the work done for the benefit of each during the month varies.

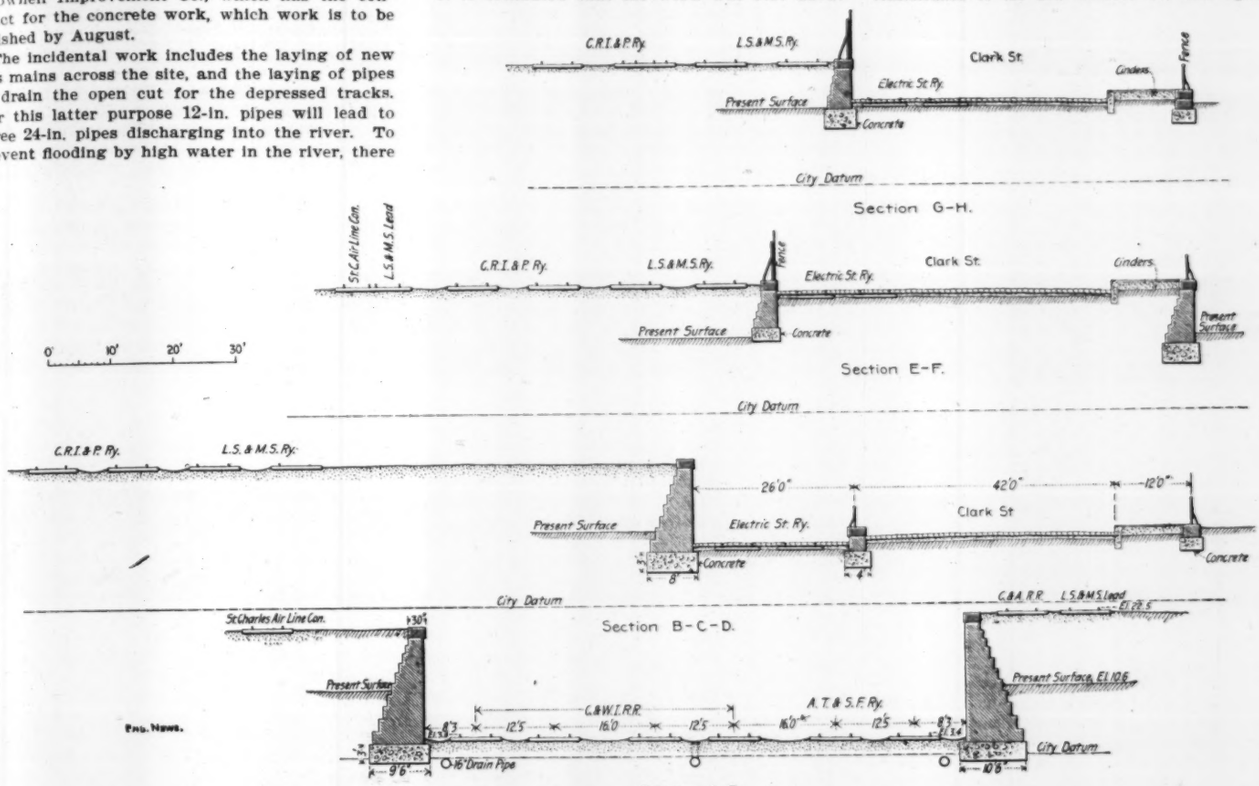

FIG. 2.—CROSS SECTIONS SHOWING ELEVATION AND DEPRESSION OF RAILWAY AND STREET GRADES.

THE NEWFOUNDLAND RAILWAY CONTRACT, entered into on March 15, 1898, between the Governor of Newfoundland and Mr. Robert G. Reid, of Montreal, is briefly presented, as follows, by Mr. M. J. Carter, U. S. Consul at St. Johns: In 1893 Mr. Reid contracted to build certain railways in this island for the government and received in land subsidies 2,500 acres per mile of road. By the present contract Mr. Reid controls the whole 775 miles of railway in Newfoundland for 50 years, and is to maintain and operate them under fixed maximum rates for transport of passengers and goods, and a subsidy of $42,000 per annum for mail service. In consideration of these obligations the government grants him in fee simple, in addition to the subsidies received in 1893, 5,000 acres of land for each mile of main line or branch throughout the entire system operated. These lands will be laid off in blocks one mile in length and ten miles deep, on either side of the line; the contractor and the government alternately selecting the blocks. Mr. Reid agrees to renew the rails on certain lines to the extent of $100,000, and to build a new branch from Topsail to St. Johns for $15,600 per mile paid by the government. For improved mail steamer service the government grants special subsidies; it transfers to the contractor the St. Johns dry-dock, for $325,000, and gives him control and management of the government telegraph lines, until April 15, 1904, on payment of $10,000 per year, and after that, to the end of the 50-year lease, the contractor must maintain these lines free of cost to the colony. The contractor agrees to have an electric railway built in St. Johns, while the government is to pave certain streets at a cost not exceeding $140,000. All disputes are to be referred to two arbitrators appointed by the two principals, and a third named by the Supreme Court. In consideration of the new contract Mr. Reid agrees to reassign and transfer to the government, at the end of 50 years, 2,500 acres of land for each mile of railway, to be deducted out of the land subsidies. The properties transferred to Mr. Reid, exclusive of land, cost the Newfoundland government as follows: Railways, $12,000,000; St. Johns dry-dock, $600,000; telegraph lines, $130,000; total, $12,730,000. For this Mr. Reid pays $1,000,000, out of which subsidies are to be returned for improvements. The government losses in operating these properties, per annum, were estimated as follows: On railway, $300,000; on telegraph lines, $18,000; on St. Johns dry-dock, $20,000; a total of $338,000 per year.

PRIZE DESIGNS FOR ARTISAN HOMES are requested by the Executive Committee of the Twentieth Triennial Exhibition of the Massachusetts Charitable Mechanics' Association. The prize offered for the best design is $750, taken from a fund provided by Dr. Geo. C. Shattuck. The nature of the work required is described as follows:

Upon a city block, 200 × 800 ft., surrounded on the four sides by streets, it is required to develop a scheme for housing, under the requirements of the Boston Building Laws, in the most convenient, sanitary and economical way, in other than a single structure, such number of artisan households as will promise a fair income on the investment. The land is to be reckoned as costing $1.50 per ft., and the rentals paid are to be considered as follows: Single room, $1.00 per week; two rooms, $1.50 per week; three rooms, $2.00 per week, and four rooms, $2.50 per week. It must be borne in mind that suites of four rooms are more in demand than smaller suites, and that single rooms are in comparatively little demand.

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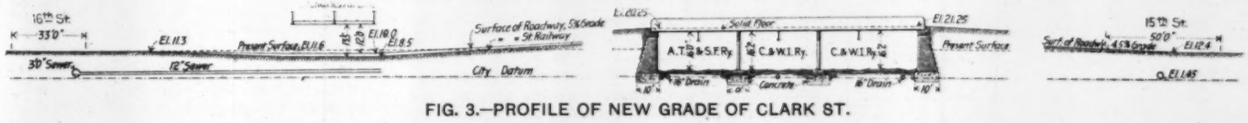


FIG. 3.—PROFILE OF NEW GRADE OF CLARK ST.

TRACK ELEVATION AND DEPRESSION AT THE 16TH ST. CROSSING, CHICAGO.

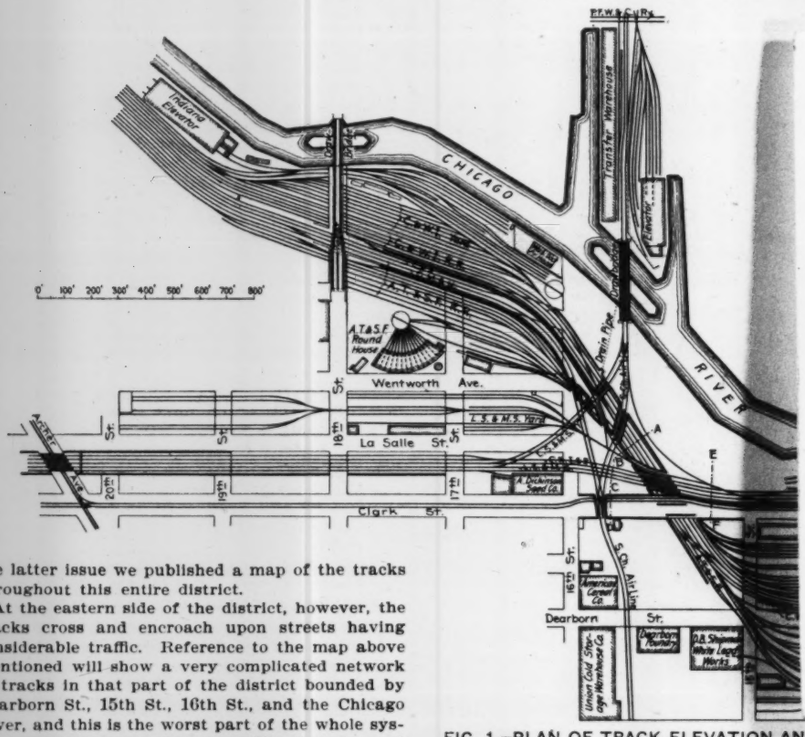
One of the most extensive and complicated systems of railway tracks in the world is that which occupies the district along the Chicago River, from 14th St. to 22d St., which district contains the freight and terminal yards of a number of railways, and through which run a multitude of main tracks, crossing and connecting in a most bewildering manner. In fact, if a person undertakes to walk across this district he finds it somewhat difficult to keep his bearings. On the large proportion of this district, which is devoted exclusively to railway purposes, there is little need of track elevation, and safety to the train service entering and leaving the district is ensured by a complete interlocking switch and signal plant established at the outlet at Stewart Ave. and 21st St. This plant was described and illustrated in our issues of Sept. 22, 1892, and Nov. 16, 1893, and in the latter issue we published a map of the tracks throughout this entire district.

At the eastern side of the district, however, the tracks cross and encroach upon streets having considerable traffic. Reference to the map above mentioned will show a very complicated network of tracks in that part of the district bounded by Dearborn St., 15th St., 16th St., and the Chicago River, and this is the worst part of the whole system, as there is a constant traffic of trains and switching movements, interfering with and endangering the street traffic. It is this section of the district which is dealt with in the present article. The interlocking plant above mentioned does not protect any tracks or crossings north or east of 18th St., and the railway crossings of this section were protected only by flagmen, while the Clark St. crossing was protected by gates.

This particular section, known as the 16th St. crossing, is probably the most complicated system of grade crossings in Chicago. It comprises a network of connecting and intersecting tracks, over which there is a continual traffic, including main line and suburban passenger trains, freight trains, light engines, and freight and passenger switching movements, to say nothing of the constant service of electric cars on Clark St. There is a daily movement of 5,000 cars and 500 engines, and the passage of this crossing was often enough to try the nerves of the street car passengers, who beheld engines and trains apparently moving upon them from all directions.

At this point the parallel tracks of the Chicago, Rock Island & Pacific Ry. and the Lake Shore & Michigan Southern Ry., running south from the Van Buren St. terminal station, and close to the west side of Clark St., are crossed diagonally by the tracks of the Atchison, Topeka & Santa Fe Ry. and the Chicago & Western Indiana R. R., which start from the Polk St. passenger terminal station and the various freight yards east of Clark St. Just beyond, the roads first mentioned are crossed at right angles by the tracks of the Chicago, Madison & Northern Ry. and the St. Charles Air Line (Illinois Central R. R.), which connect with the Illinois Central R. R. main line tracks on the lake front. These are not merely crossings, but every line is connected with every other line and with numerous freight tracks in order to provide for the interchange of cars between the various roads. Some idea of the traffic may be gathered when it is explained that, in addition to the roads named, the trains of the New York, Chicago & St. Louis Ry. now run into the Van Buren St. terminal station, and that the Chicago & Western Indiana R. R. is a terminal road used by no less than seven railways (the Atchison, Topeka & Santa Fe Ry., Chicago & Eastern Illinois R. R., Grand Trunk Ry., Chicago, Indianapolis & Louisville Ry., Erie R. R. and Wabash R. R.).

When the city of Chicago undertook in earnest the elimination of the numerous grade crossings of the streets by compelling the railways to elevate their tracks, this crossing came up for consideration, but the difficulties of preparing a satisfactory plan which would be accepted by the city and by all the railways interested were so great that the matter has been laid aside from time to time until the present year, when, by agreement, the entire work was put into the hands of Mr. James Dun, M. Am. Soc. C. E., Chief Engineer of the Atchison, Topeka & Santa Fe Ry. The difficulties arose largely from the fact that it was desired, in making the change, to separate the grades of the different railways, and thus, as far as possible, eliminate track crossings as well as highway crossings at grade. Considering that the tracks had still to be connected by switches and turnouts, it will be seen that the problem to be solved was difficult and complicated. The plans were finally agreed upon, however, by all parties concerned. Work was commenced on April 24, and is to be completed this season. Major G. W. Vaughn, M. Am. Soc. C. E., is the Engineer in Charge.



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The accompanying plan, Fig. 1, shows the arrangement of tracks as it will be when the work is completed. The four tracks of the C., R. I. & P. Ry. and the L. S. & M. S. Ry. (running north and south), will be elevated about 12 ft., as a continuation of their track elevation which now extends north from Englewood to 16th St. (Eng. News, March 17.) The six diagonal tracks (two for the A., T. & S. F. Ry. and four for the C. & W. I. R. R., and the lines using it), will be depressed about 9 ft., passing under the elevated lines and under Clark St. in an open cut with vertical concrete retaining walls. The St. Charles Air Line and C., M. & N. Ry. will be elevated, so that there will still be one railway crossing at grade, a double track line crossing four tracks at right angles. The arrangement makes it necessary to change the grade of Clark St., which will be raised to pass over the depressed tracks and then inclined downward to pass under the elevated tracks of the St. Charles Air Line. The elevation of this latter line has made it necessary to raise the grade of the South Side Elevated R. R., which crosses it just east of State St.

On Fig. 2 are shown some cross sections which explain the relations of the several railway

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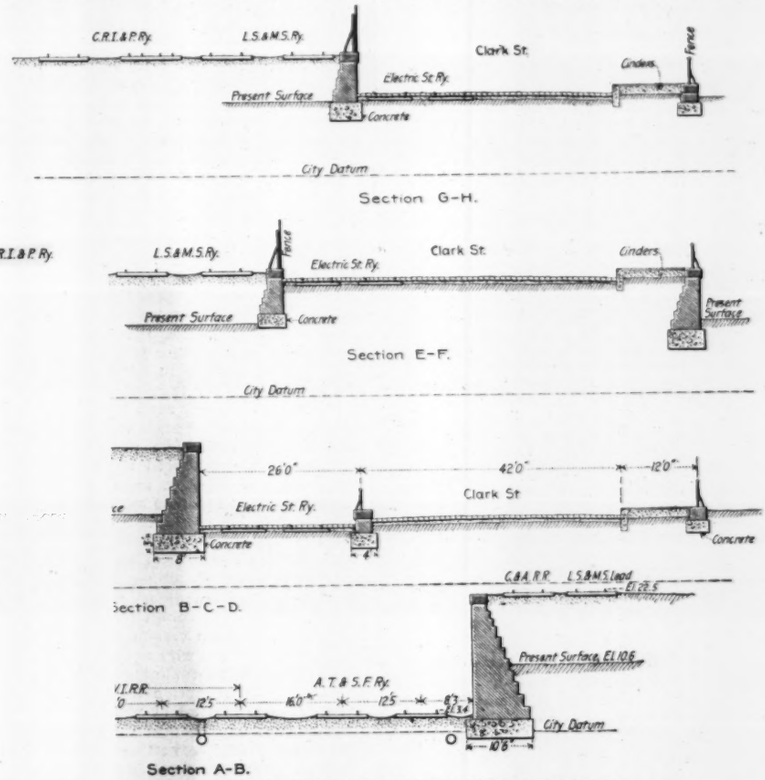

Section A-B.

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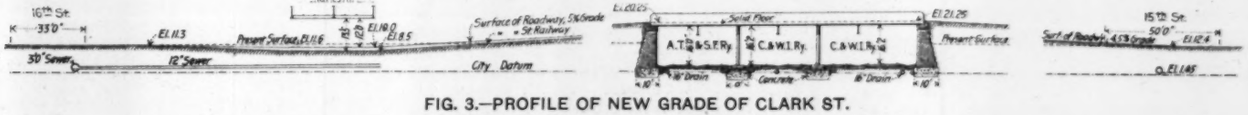

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The report of the board of officers appointed to examine the wrecks of the four Spanish armored cruisers, sunk off Santiago, makes interesting reading to naval experts throughout the world. There has never been so good an opportunity to test the efficiency of modern warships and their armament in actual combat, and as a result some remodeling will be necessary in the design of future ships of this class. One of the most important lessons taught is that torpedo tubes on battleships and cruisers, at least when located above the water-line, not only introduce an unnecessary complication into the armament, but form a great and positive danger to the ship itself. The report shows that the Spanish cruiser "Vizcaya" was practically destroyed by one of her own torpedoes; and while it is not stated whether the explosion was brought about by the direct impact of a projectile, or by the fire resulting from the explosion of the shells from the attacking fleet, the fact remains that several hundred pounds of gun-cotton did explode on this ship and wrought greater havoc than the hail of projectiles to which she was subjected.

The enormous value of rapid-fire batteries is attested in this battle where four ships protected by 12-in. armor belts were destroyed. It appears that only one 12-in. projectile struck any of these vessels, and yet they were destroyed in a comparatively short time. The terrific and accurate fire of our sailors drove the Spaniards from their guns, killed many men, pierced the parts unprotected by the heaviest armor, and set fire to one after another of the Spanish ships. The fact that fire played such an important part in the destruction of at least two of the Spanish ships fully justifies the efforts of our naval authorities in reducing the amount of woodwork on battleships to a minimum, and leaving it out entirely wherever possible. Early in the Santiago fight the water pipes on the "Infanta Maria Teresa" were broken, and when a bursting 6-in. shell set her on fire there was no way of putting it out.

As a result of the Santiago fight it is very evident that rapid and accurate gun-fire, combined with speed in the vessels and good seamanship, will virtually decide the battle of the future before the heavy ships can approach each other near enough to use a torpedo on the enemy's hull. Hence, torpedoes on this type of vessel are useless as a means of attack, and dangerous when exposed to the long-range fire of an enemy. The accuracy of the Yankee gunners is shown by the fact that the "Almirante Oquendo" was struck 66 times in the parts of the ship not now submerged; the "Infanta Maria Teresa" contains 33 shot-holes, the "Vizcaya" 24, and the "Cristobal Colon," which was purposely shielded by the others, was struck 8 times in the hull. The torpedo boat destroyers were so completely wrecked by our projectiles that they are beyond all hope of raising. We can honor the reckless valor of the Spanish admiral and his men, and regret the destruction of so much valuable property; but the experience is extremely useful in the design of our future naval armaments, and the United States, as in 1862, has the opportunity to teach European nations a few things relating to ships and guns that they did not know before.

The American wire rod industry has had a remarkable history. Previous to 1882 nearly all the rods made in the United States were imported, the importations reaching nearly 200,000 tons in one year. In 1882 a rod mill was built at the Cleveland (O.) Rolling Mill by Mr. William Garrett, which was far in advance of any other mill in its capacity for turning out product at a minimum cost for labor. Soon Mr. Garrett was building new mills at other steel works, each one an improvement on the one preceding. In 1897 the United States produced nearly 1,000,000 tons of rods, 80% of them in mills of the Garrett type, and American rods are exported to every quarter of the globe. The sequel to this story is now told by the "Iron Trade Review," which says that Mr. Garrett has been occupied abroad for the past six months in equipping foreign manufacturers with American machinery which will enable them to meet American competition. An improved Garrett mill has been erected at Havre, France, and one of the largest wire rod manufacturers in Germany is about to duplicate the twin mill at Joliet, Ill., with the exception that it will begin rolling with a 5-in. instead of with a 4-in. billet. It is apparent from this that the French and German manufacturers are getting ready to put a stop to the exports of wire rods from the United States into European markets.

The far-reaching importance of the application of electric traction to street and suburban railways, which has been made in the past decade, is well pointed out in a recent article in the St. Louis "Globe-Democrat." The writer makes the reasonable assumption that the average city worker cannot afford to spend more than an hour in transit between his home and his business, and this unit of time practically limits the availability of suburban districts as economic places of residence. With the old horse-car a speed of 6 miles an hour was the best attainable, and from any one center this gave a diameter of 12 miles and an area of about 110 square miles for the district within an hour of the central business section. Electric traction, however, increases the rate of speed to 10 miles per hour, and the area within an hour of a given center to over 300 square miles, or nearly three times the area accessible in this time by the horse-car. The electric car has thus much the same influence on the growth of cities that the horse-car originally had when it did away with the old-time necessity of living within walking distance of one's place of work. The benefit to the workingman in both cases was the possible removal of his home from crowded and unsanitary centers to a location in more remote, cheaper and healthier districts. While in Europe street railway rates are regulated by the distance traveled, as on steam railways, the American system of uniform fare provides for a short ride at a comparatively high rate, and very cheap long distance travel. Thus, the extension of the one hour radius by the application of electricity does not, as a rule, increase the rate of fare.

There is no doubt as to the widespread benefits resulting from the use of electricity on suburban lines; both to the workingman, in providing cheaper and better houses, and to the community at large by increasing property values in converting agricultural land into building sites. But our contemporary omits consideration of one important element in comparing the speed of the electric car and the horse-car and the areas affected. In our issue of June 11, 1896, Dr. Louis Bell presented a study of the City of Boston and its suburbs, showing the areas within 15 and 30 minute distance of the business district by both horse and electric cars. Dr. Bell showed that in crowded business centers the average speed of both vehicles is almost the same for the first 15 minutes at least, the common rate being about 6 miles per hour. But for the second 15 minutes the electric cars gain over the horse-cars, in proportion as the streets become less crowded with business traffic; and, in the case of Boston, 57% is added to the area accessible within one-half hour's travel by the application of electricity to street railways. While this practical study of actual conditions considerably modifies the comparison of relative speeds and of residence areas assumed by our contemporary, it does not upset its general conclusion of great gain to the public by the use of electricity.

There is still another way in which the electric car has operated to build up suburban districts which is not alluded to by either Dr. Bell or the journal referred to above. We refer to the building up of manufacturing districts in the outskirts of cities where land for factories, yards, and warehouses, and for employees' dwellings can be had at a small cost, and where by means of electric railways the city itself is still within easy reach. Under the old conditions, it was difficult to induce workmen to leave the crowded city with its social attractions, and its opportunities for cheap purchases; and there were also disadvantages in locating a manufacturing establishment where communication with the business center was difficult. The electric car has removed both these obstacles, and the influence it has had in building up manufacturing suburbs is not the least of the benefits it has brought.

A conservative view of the possibilities of utilizing garbage as a fuel for electric light stations is taken by Mr. Jos. Lobley, M. Inst. C. E., Borough Engineer of Hanley, England, in a recent report. Several of his main points are very much the same as some made by us in an editorial discussion of the subject in our issue of Aug. 26, 1897. Mr. Lobley urges that the total amount of power now required by the local electric lighting plant at Hanley is about 1,150 HP., and that this will soon be greatly increased. He figures on only 100 HP. as available from the refuse destructors, after satisfying the demands for power at the garbage plant. He proposes to install a generator at the proposed garbage plant for the generation of 100 HP. to be used for the day load on the electric station. The two plants cannot be operated together owing to the lack of a suitable site. Mr. Lobley conveys the idea that the only combined garbage burning and electric lighting plants actually installed in England thus far are the two at St. Pancras and Shoreditch. The St. Pancras combined plant shows for the year a cost per electric unit of 1.33d., against 0.76d. at another electric light station owned by the same authorities where no garbage is used. The conditions at St. Pancras, however, are said to be unfavorable for the combined plant. At Shoreditch results for anything like a year were not available when Mr. Lobley's report was written, but he points out that a large expenditure was made there for storing heat, which of course means heavy capital charges. One point made by Mr. Lobley is well worth quoting, as follows:

> Though the generation of electricity by steam raised by the burning of house refuse may have good economical results in certain places, I am inclined to think that the spare heat evolved will be better utilised in the future by improvements that may be brought about in the destruction, or preparing for destruction, of the refuse itself. In other words, this means that a given number of cells will do the work now performed by a greater number.

The remarks quoted appear to be especially applicable to this country, where less progress has thus far been made in reducing the fuel cost of garbage cremation than is the case in England.

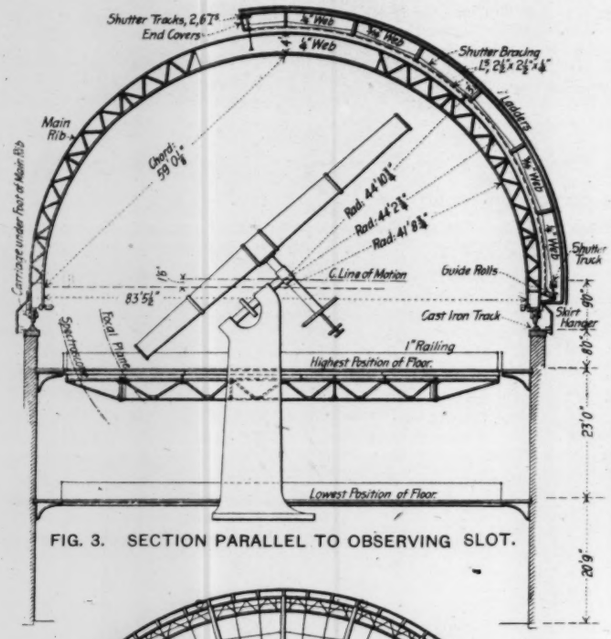


FIG. 3. SECTION PARALLEL TO OBSERVING SLOT.

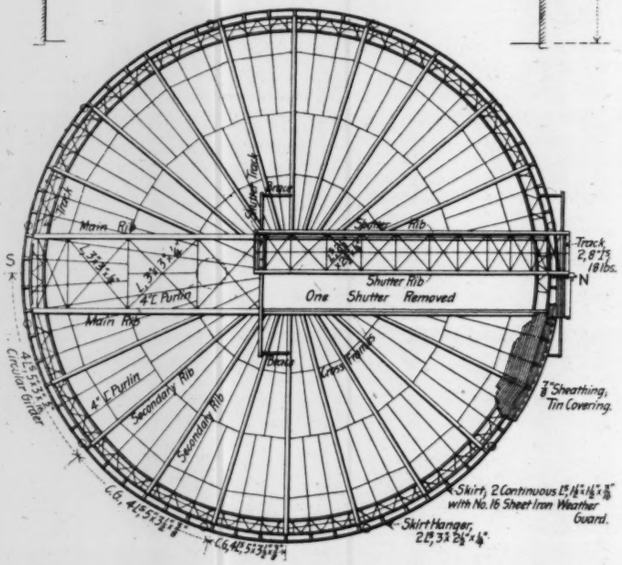


FIG. 2. PLAN OF STEEL FRAMING FOR DOME.

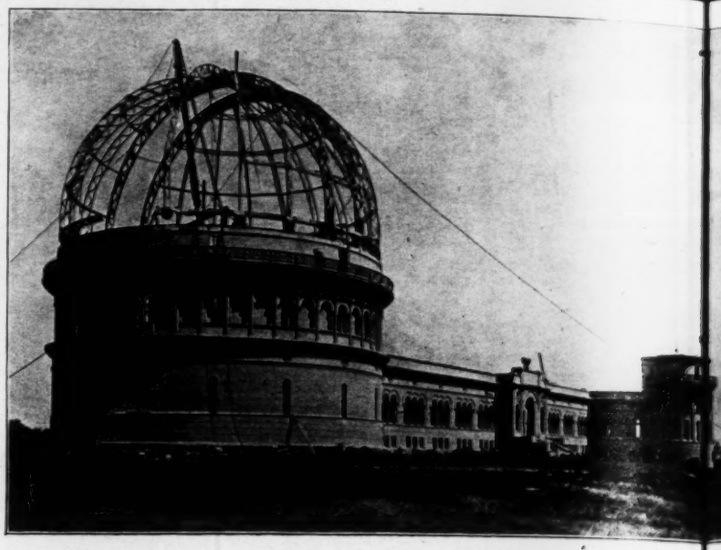


FIG. 9. ERECTION OF SMALL ARCH WITH WHEEL ATTACHED.

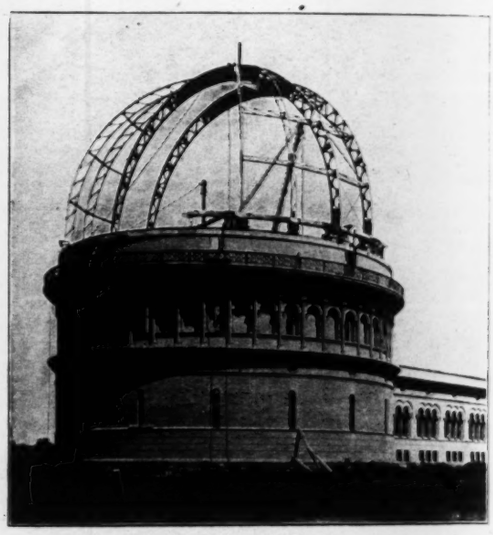


FIG. 8. DOME WITH MAIN ARCHES ERECTED.

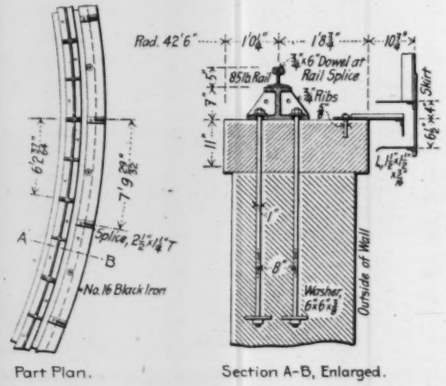


FIG. 4. DETAIL OF CIRCULAR TRACK.

STEEL DOME FOR THE YERKES OBSERVATORY, LAKE GENEVA, WIS.

Warner & Swasey, Cleveland, O.,
General Contractors.

King Bridge Co., Cleveland, O.,
Contractors for Structural Work.

R. S. Wright & Co., Pittsburg, Pa.,
Contractors for Erection.

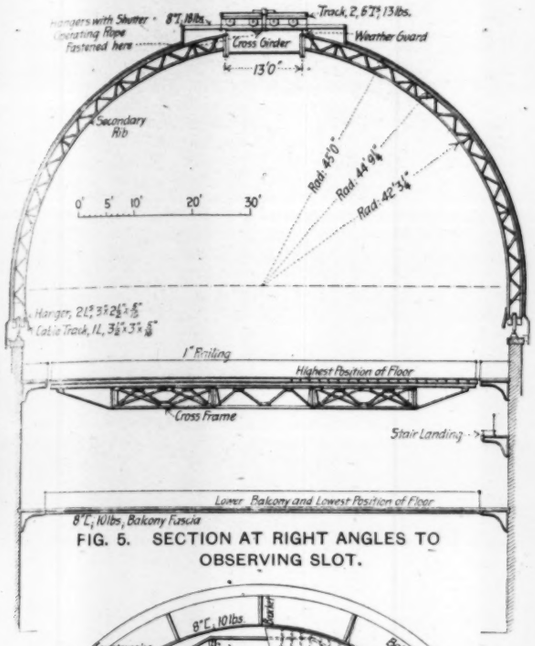


FIG. 5. SECTION AT RIGHT ANGLES TO OBSERVING SLOT.

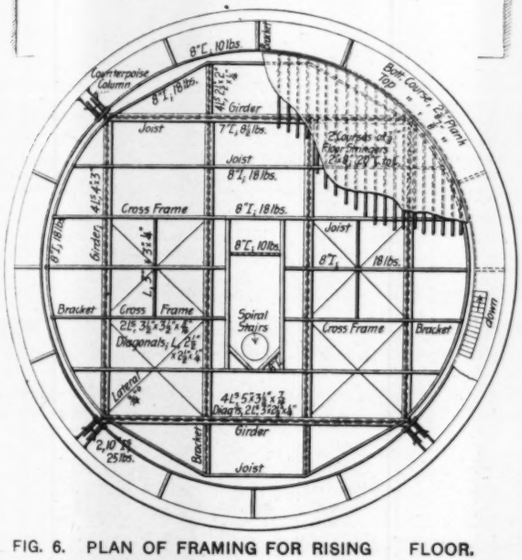


FIG. 6. PLAN OF FRAMING FOR RISING FLOOR.

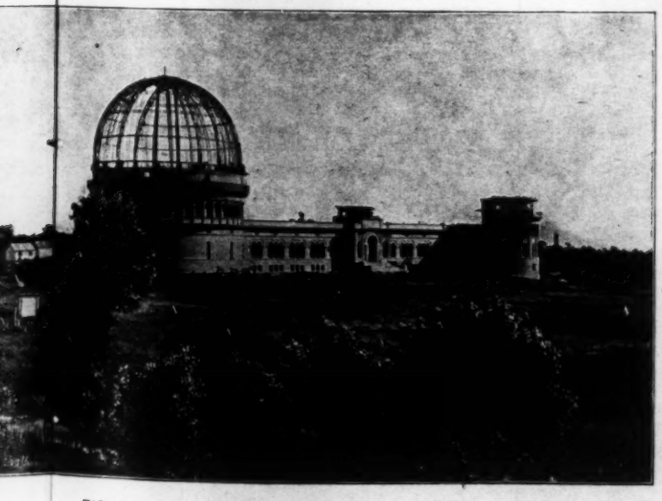


FIG. 1. GENERAL VIEW OF OBSERVATORY.
(Steelwork for the 90-ft. Dome alone Erected.)

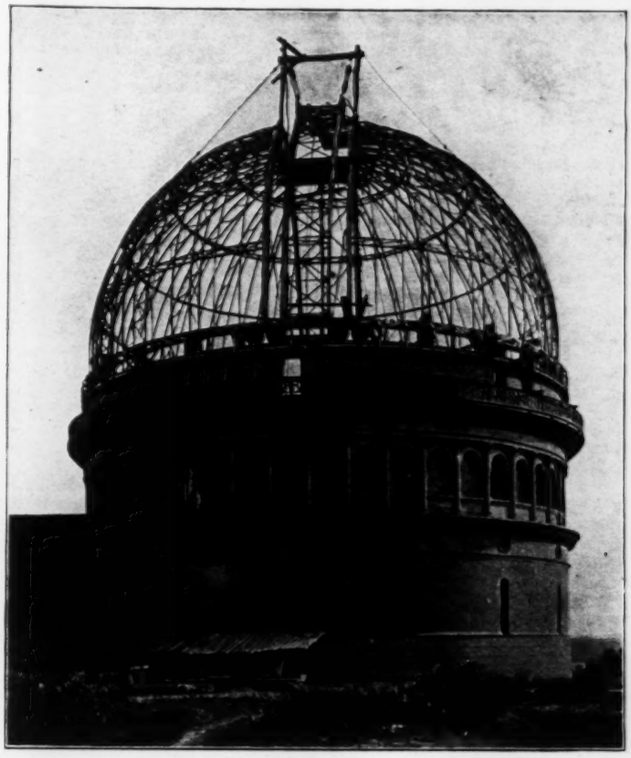


FIG. 10. DOME FRAMING COMPLETE AND SHUTTERS BEING ERECTED.

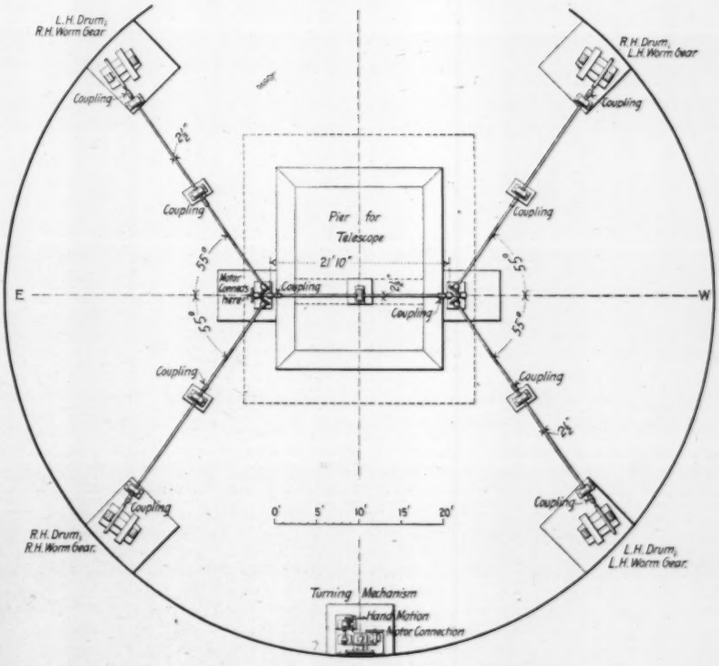


FIG. 7. PLAN OF OPERATING MACHINERY IN BASEMENT OF TOWER.

and scarcely anything of practical value has been accomplished in utilizing heat for the operations of the garbage disposal works themselves.

Manufacturers who wish to do an export business must have their circulars and catalogues translated into foreign languages, but care should be taken that the translator is not only a good linguist, but also an expert in the particular business to which the documents to be translated refer. Otherwise the translation is apt to be a matter of ridicule to those to whom it is sent. We cannot well give an instance to show how an English circular might be translated into bad German, for example, but the London "Engineer" gives us the following illustration of a translation from another language into English which is probably no worse than many translations from English:

"We pique ourselves," says the circular, "on making you known that the sale of the —— has, by us, undertaken. This preparated, exclusively arranged by some vegetables, is entirely spoiled about something hurtful to the steam boiler blades. By our preparated every calcarious substance is neutralized, reducing it to power, and at the same time steam boiler blades are conserved from the usual corrosion, not only, but the ebullition, is totally avoided, as it appears about some very interesting experiments, which have been made in several establishments." In conclusion the circular adds: "To be willing, this preparated may be decomposed."

THE PREVENTION OF STEAMSHIP COLLISIONS.

The disaster to the transatlantic steamer "La Bourgogne," on July 4, by which 560 of her passengers and crew lost their lives, is the most serious marine disaster, with respect to the number of persons lost, that has occurred for many years. So far as we have been able to find, no such great loss of life has occurred in an ocean steamship accident since the White Star steamer "Atlantic" was wrecked on the coast of Nova Scotia, on April 1, 1873. The number lost on that vessel was almost the same as on the unfortunate "Bourgogne."

The terrible loss of life in this accident calls world-wide attention to the greatest danger which now attends ocean travel, that of collision, and to the possible means of guarding against it. The other dangers which formerly attended ocean travel have been greatly reduced by the stanch construction of modern steam passenger vessels, by the perfection which has been reached in propelling machinery, and by the extent to which navigation is now assisted by signals upon the coasts of all civilized countries. The danger of collision, however, has been greatly increased by the improvements in ocean navigation. In the days when the sailing packet was the fastest method of passenger travel by sea, collisions were almost unknown. It was not possible with sailing vessels to follow so closely the shortest route in a trans-oceanic voyage; and in a fog, when collisions usually occur, a sailing vessel is either stationary or moving slowly with light winds.

The danger of collisions is, in fact, almost entirely an outgrowth of the conditions of steam navigation. The number of vessels plying on the ocean has greatly multiplied, the size has been increased, they run in closely-defined routes, and most important of all, the energy stored in the swiftly moving bulk of a modern passenger steamship has become so enormous that her engines cannot check her headway till she has gone a long distance, and if she strikes another vessel the force exerted is so great that no construction that can possibly be devised can resist it without serious injury.

Of course much can be done, and is done, by the best steamship designers to reduce the dangers that result from any injury to a vessel's hull. The division of the hull into water-tight compartments, and the adoption of a bow projecting above the water-line to absorb part of the shock of a collision before the space below the water-line has to suffer, are examples of the methods adopted to reduce the danger of loss from collision. But water-tight compartments are not always water-tight. Bulkheads are essentially emergency constructions, not likely to be actually put to use in the entire life of the vessel. Naturally the tendency is to make them as light as possible. An experienced marine architect, not many years ago, expressed the opinion that a large proportion of ship bulkheads would be so strained as to leak badly if the compartment of the hull on one side were filled with water, and that adjoining were empty. If this is true of the uninjured structure, what are the probabilities when a ship has suffered such a shock as that which sent "La Bourgogne" to the bottom? Such a shock must inevitably strain every plate and rivet anywhere near the point where the blow is received. Doubtless improvements will be made in the hull construction; but there appears no reason to expect more than a trifling diminution in the dangers of collision on account of improvements in this direction.

We have alluded to the fact that steam vessels are able to keep very closely to the shortest route in sailing between two ports. It is manifest that this tends to bring two vessels sailing between the same ports, but in opposite directions, in danger of collision. In the case of the much-traveled path between the principal American ports on the Atlantic seaboard and the chief ports of England, France and the North Sea, the danger has become so manifest that most of the transatlantic steamship companies have agreed to use different routes for east bound and west bound vessels. It is stated that the French Line, to which "La Bourgogne" belonged, is the only one of these companies which did not join in this agreement. The ill-fated "La Bourgogne," when struck by the "Cromartyshire," on July 4, was not only about 160 miles north of the course usually taken in the summer by eastbound steamers from New York, but was from 60 to 90 miles north of the usual route of the west bound vessels. The route on which "La Bourgogne" was sailing is nearer the short, great circle course, it is true; but besides putting a vessel in the track of steamers proceeding in a contrary direction, the more northern route is much more subject to fogs and icebergs than the southern. It is probably safe to say that after the bitter lesson it has had, the French Line will conform to the general custom and send its vessels eastward on the usual course pursued by other vessels.

On the other hand, it is well to point out that the fixing of different routes for vessels sailing in opposite directions, important though it is, still leaves large risks of collisions unaffected. Naturally such a separation of routes will only be made in the case of the most traveled ocean lanes, and even where such a separation is made and observed, there is still chance of collision where the course is crossed by that of vessels sailing for other ports, and by vessels which are driven by stress of weather from the usual path, or which go astray in their reckoning.

Whatever blame may attach to the managers of the French Line, for adopting their present east bound course for their vessels, it seems to us that we shall be getting much nearer to the important cause of this terrible calamity if we emphasize the fact that the vessel at the time of collision was running at high speed through a thick fog. This disaster makes plain the risk that always attends this too common practice.

According to the best information, the ill-fated steamship was steaming at a speed of 17 to 18 knots when she collided with the "Cromartyshire," a sailing vessel which was drifting before a light breeze at a speed of only four or five knots, and which was hardly one-fourth the size of the big French liner.

It is a popular excuse for the maintaining of high speed in fogs, that it is really safer for the fast vessel to do so, as she will cut down anything she may run foul of with little injury to herself. The fishing schooners on the Newfoundland Banks have a well-founded hatred of the great steamships, which come flying through the fog at railroad speed, and which are believed to have sent many a sailing vessel's crew to a watery grave. But the sinking of "La Bourgogne" proves that the theory of making the Atlantic greyhound into a projectile to protect her from collisions does not always work. It was the French steamer's high speed and enormous momentum that caused her own destruction, when she fouled the drifting sailing vessel. With the experience of "La Bourgogne" fresh in mind, steamship companies can no longer claim that it is the safety of the great number of lives in their care that causes them to maintain high speed in fogs, notwithstanding the dangers in which other vessels are placed by their action.

It is fair to say, however, that in this matter the French Line is no more at fault than every other transatlantic steamship company, so far as we know. One has but to see the regularity with which these vessels come into port, notwithstanding the fogs that are so frequently encountered, to appreciate the fact that the so-called slacking of speed in fog really amounts to very little. When one considers the great distance which a vessel at a 15 to 17-knot speed will run before her reversed engines can absorb her headway, it is easy to see that for the fast liners to slow down two or three knots in a fog really accomplishes little in the way of added safety. It is said that in one recent case the Courts have held that a speed of 10 knots in a fog was excessive; and the decision seems in accord with sound engineering. If a high-powered steam vessel slows down to a speed of 7 to 8 knots in a dense fog, she can pretty surely be brought to a stop before striking a vessel ahead after the lookout first hears her signals. Vessels with less powerful engines, which take longer to check their headway, ought to run still more slowly in a dense fog, if the safety of ocean travel is to be fully ensured.

Notwithstanding these plain facts, it is not likely the steamship companies will change their practice as to high speed in fogs, even with the fatal accident to "La Bourgogne" as a warning. The public demands high speed; and it is quite doubtful whether a company which should advertise that all its vessels slowed down to 8 knots in thick weather would find its passenger lists increased thereby. The steamship companies are in business to give the public what it demands. They do not run steamers at high speed because of the freight they carry, but because of the passenger list. If the travelers on ocean steamships manifest a strong preference for slower and safer voyages, the companies will doubtless be found ready to meet the demand; such a change would mean, doubtless, a lengthening of the time schedules, to make allowance for possible or probable delays by fogs. Both for their own profit and the convenience of their passengers the steamship companies strive to move their boats with the greatest regularity. If a 7-day boat is delayed two days by slowing up for fog, it may not be possible to get her cargo removed and the new lading in in time for her start at the scheduled hour on the return voyage. But a lengthening of the time schedule, means fewer trips for a vessel during the season, and a reduction in its earnings.

Taking all these things into consideration, it does not seem probable that steamship companies will generally adopt the practice of running at a safe speed during fogs. We must look for greater safety, then, in the direction of improvements in the methods by which vessels approaching each other may be more surely warned of each other's presence.

The problem of making light rays penetrate a fog appears to be impossible of solution. A searchlight beam may, it is true, be seen for a considerable distance at certain times, when only a thin mist covers the water; but in such fogs as those on the Banks of Newfoundland, a searchlight beam cannot begin to reach as far as the present sound signals, and in daytime, of course, the searchlight is of no use at all.

As light waves cannot penetrate fog, we have left two possible directions in which to look for systems of signaling, by sound waves and by electric waves. The former of these is represented by the system now in use; but it is applied with a crudity which is amazing when one considers the great interests at stake. According to the present laws, steam vessels are required to sound a steam whistle at certain intervals, when enshrouded in fog, while sailing ships must ring a bell or blow a horn. The ineffectiveness of the average sailing vessel's fog warning is too well known to call for comment. On the other hand, the fog sirens, with which many light stations are equipped, can be heard for many miles out at sea, not alone because of their power, but because they are designed to concentrate the sound and project it in the desired direction.

The laws of acoustics are well known, and there is really no difficulty, not only in creating a sound of almost any desired pitch and volume, but in concentrating and directing it toward the quarter where the warning is needed. Under the present system nothing whatever is done in the way of directing the sound. In the case of the fog signal on ocean steamers, the fog whistle is usually located amidships, and the sound from it is radiated in all directions. Again, it is by no means certain that the discordant note of the steam whistle is the best form that a marine sound signal could take; some purer musical tone might penetrate quite as far and be more readily recognized.

We have alluded to the fact that electric waves can traverse a fog as well as sound waves. In the so-called system of telegraphing without wires, messages have been sent and received over a distance as great as 14 miles. It is quite within the bounds of possibility that two ships equipped with proper apparatus might be able to determine each other's presence and approximate position by means of electric waves alone, when both were enveloped in fog. We say it is possible; but it is a very far cry from this to any practical plan for the adoption of radiant electric energy as a fog signal for general use on board vessels.

An inherent defect in any such system, no matter how perfect it might otherwise be made, would be the necessity of skill and care in handling the instruments. Their derangement or failure to indicate correctly might be the source of disaster, and the same thing is true of any momentary lapse on the part of the operator. A danger signal that every man on board can see or hear is worth forty which require a skilled operator to watch a magnetic needle or a gold-leaf electroscope, whose indications attract no attention save from the one who knows their significance.

In dealing with matters of ocean navigation, it must be remembered that sailing vessels, large and small, as well as steam vessels, must be taken into account. It is visionary to expect that anything in the shape of complicated electrical appliances could come into use on vessels of this class as a fog warning, or that it would be so operated as to be effective if it were brought into use.

In conclusion, then, it appears to us that the best that can be done to reduce the danger of collision at sea is to improve the sound signals at present in use. If fast-running steamers wish to continue on their course in a fog with little or no checking of speed, let them provide themselves with some device at their bows that will project a volume of sound which will be audible for several miles ahead. Sailing vessels which are near enough to the course to hear this warning will be impelled to an instant reply with their own fog signals. It would be quite practicable for sailing vessels in such emergencies to discharge explosives which would produce a volume of sound that would reach the approaching steamer even if she were some miles away, and warn her to at once slacken her speed.

With such improvements in practice as respects the production of sound signals, might well come improvements in the system of listening for and detecting them. The "Eophone,"* by which the direction from which a sound comes is accurately located, is already in use on some American coasting vessels, and seems to deserve a more general adoption in steamship service; and it is quite possible that other inventions may make it possible to detect sounds at a greater distance than is possible with the unaided ear.

We are aware that it is exceedingly difficult to introduce anything in the shape of an innovation on board ship. There is no place where prejudice and conservatism have a stronger hold. But if owners of ocean vessels elect to risk the property and lives in their care by running at high speed in fogs, they ought to welcome every method by which the danger arising from this practice may be lessened.

Since the above was in type, we have received reports of the first day's proceedings in the official investigation of the accident. According to the testimony of the captain of the "Cromartyshire" in this inquiry, the whistle of "La Bourgogne" was first heard on board his vessel not more than ten minutes before the collision, and it was heard seven or eight times before the vessels came together. If "La Bourgogne" was going 18 knots, as claimed, this would indicate that the sailing vessel first heard the steamer when she was about three miles away. The lookout on board "La Bourgogne," however, is said to have heard the sailing vessel's foghorn only four or five times before the collision; and it does not appear that the engine was reversed, or even stopped, before the vessels came together.

If these statements are correct, our suggestion above, that sailing vessels ought to have some more efficient means of warning approaching steamers in a fog, appears to be especially appropriate to the circumstances of this disaster. It must be said, however, that if engines are not immediately reversed to check the headway of a steamer as soon as warning is heard of the proximity of another vessel, all the improvements in signaling systems that ingenuity can devise will be of small effect. We have tried to make it clear above that to run at high speed through a fog is and must always be dangerous. If steamship companies persist in taking this risk, however, they should certainly see to it that as soon as the signal of another vessel is heard, the engines are reversed to check the speed as quickly as possible. To pursue any other course is a sort of gambling with death that cannot be condoned.

*See Engineering News, Jan. 6, 1898.

LETTERS TO THE EDITOR.

Note on the Behavior of Some Cements With Diluted Hydrochloric Acid.

Sir: Having occasion recently to analyze certain cements, it was noticed that some on treatment with hydrochloric acid, gave off hydrogen sulphide, while others gave off free chlorine. In all seven cements were examined: four Portland and three natural cements. All were well-known brands and most of them had been tested with satisfactory results in the engineering laboratory of this university. It was found that all of the Portland cements gave off hydrogen sulphide, while all of the natural cements gave off chlorine.

It was assumed that the evolution of hydrogen sulphide indicated the presence of a sulphide or of a compound of the nature of the ultramarine pigment, and that the evolution of chlorine indicated the presence of a peroxide.

As neither a sulphide nor a peroxide appeared in the reports of analyses found in the literature consulted, it was thought worth while to determine the amounts of hydrogen sulphide and chlorine given off, respectively.

The following table gives the results, which are in all cases the average of well agreeing duplicates:

Portland.	Sulphur given off as hydrogen sulphide.	Correspond'g to calcium sulphide, (Ca S.)
Marked "La Farge"	0.05%	0.11%
" "Giant"	0.04%	0.09%
" "Alsen"	0.02%	0.05%
" "Belgian"	0.02%	0.05%

Natural.	Chlorine.	Correspond'g to manganese dioxide ($Mn O_2$.)
Marked "N. Y. & Rosendale"	0.25%	0.31%
" "Hoffmann"	0.23%	0.28%
" "XXX Rosendale" .	0.20%	0.24%

Although the amounts of hydrogen sulphide and of chlorine are so small, one or the other could be detected in every case by the sense of smell, and by the usual simple chemical tests.

Walter E. Pettigrew, C. E.

New York University, June 27, 1898.

The Effect of Temperature on the Flow of Water Through Soils.

Sir: In connection with the letter in your issue of June 30, from Prof. L. G. Carpenter, upon the effect of temperature upon the flow of water through soils, I beg leave to call your attention to the formula which I have commonly used, and which was referred to in the editorial article in your issue of May 12. This formula is as follows:

$$\text{Temperature factor} = \frac{t\ (\text{Fahr.}) + 10}{60},$$

unity being taken as the velocity of flow at a temperature of 50° F.

In the following table are given the temperatures and velocity factors, as computed by Prof. Carpenter, from the formula of Poiseville, together with the temperature factors as determined by my formula, and also these last multiplied by 1.36, this being approximately the factor representing the difference between the standard temperature of 50°, which is taken as the basis of my formula, and the standard temperature at the freezing point, as in the formula of Poiseville. As the factors express only the relative flows at different temperatures and have no absolute significance, the introduction of a constant factor is unimportant.

Temperature, degrees, F.	Temperature factor, $\frac{t+10}{60}$	Multiplied by 1.36.	Factor as given by Prof. Carpenter.
32	0.700	0.952	1.000
42	0.867	1.179	1.195
52	1.033	1.405	1.403
62	1.200	1.632	1.625
72	1.367	1.859	1.860
82	1.533	2.085	2.109
92	1.700	2.312	2.372

It will be noticed that for temperatures between 42° and 82°, the differences between the two formulas hardly amount to 1%, and this is the range of temperature for which most calculations of this class are made. For temperatures but little above the freezing point my formula gives considerably lower results than the other.

I do not know upon what data the formula of Poiseville was based. My own was based solely upon experiments which I personally executed, with the flow of water through fine sands at carefully controlled temperatures, and the results were afterward checked by very numerous experiments upon the flow of water through long and fine capillary tubes under constant pressures and completely immersed in water kept at exactly the desired temperature. The results thus secured evidently followed the same law as the results obtained with sand, and were more accurate, owing to more perfect control of all the conditions, and were thus taken as the basis of the formula.

These experiments were carried out from the freezing point, with the whole apparatus packed in ice, to the highest summer temperatures. All of the results agreed very closely with the formula as given, and I am strongly of the opinion that it is very nearly correct for all temperatures between the freezing point and 100° F. I am also of the opinion that it applies to the flow of water through soils, or through long and fine passages. It applies also to fine gravels, as far as the rate of flow is influenced principally by the viscosity of the water. With coarse gravels and high rates other factors than viscosity exert controlling influences, and the temperature factor disappears.

Very truly yours, Allen Hazen.

St. Paul Building, New York, June 30, 1898.

A NEW FORMULA BY BAZIN FOR COMPUTING FLOW OF WATER IN OPEN CHANNELS.

In the "Annales des Ponts et Chaussees," for the fourth quarter of 1897, Mr. H. Bazin, Inspector General of Bridges and Roads, gives a new formula, for calculating the flow, or delivery, of water in open channels, which he believes is less complicated and of wider general application than those now in use. Space forbids our giving the full paper, with all its accompanying experiments; but the new formula and the reasons for deducing it may be briefly set forth as follows:

After discussing the difficulties besetting the problem of fairly meeting all conditions, Mr. Bazin says that the simplest, monomial formula is:

$$A = \alpha + \frac{\beta}{R} \qquad (1)$$

In which A is an abridgment of the relation $\frac{RI}{U^2}$, and α and β are two constants; in these and other formulas, R = the mean radius; I = the slope, and U = the mean velocity. The above formula was adopted by Mr. Darcy as the result of his experiments upon pipes, in 1850; and it answered well for pipes, by reason of the constancy of the transverse profile, always circular, and because of the relative smallness of the coefficiet β. But it is less applicable to open channels, owing to the diversity of profile and the nature of the sides causing α and β to vary within very wide limits. It must be admitted that this formula is open to a double objection. It provides for no relation between α and β, the last coefficient increasing very rapidly with the roughness of the sides; and, if we assume that the mean radius R increases indefinitely, A would be different for each kind of side. But it would seem, on the contrary, that if the width of a channel were increased while the sides remained identical, the inequalities of the sides should be gradually effaced as the dimensions of the bed increase. As a consequence, the values of A, for all the broad divisions of side roughness, should progressively approach each other and converge towards a common limiting point.

As it is impossible to find a simple relation between α and β, Mr. Bazin proposes, in Equation

1, to replace A and R by their square roots, which vary less rapidly. He then has

$$\sqrt{A} = \alpha + \frac{\beta}{\sqrt{R}} \qquad (2)$$

We are enabled to obtain a sufficient approximation by assuming that α remains constant, and that the values of A, for the different states of the sides, always converge towards the limit α. The coefficient β then alone varies, becoming thus the characteristic of the degree of roughness of the sides.

In 1889, Messrs. Ganguillet and Kutter approached Equation 2 by writing it under the equivalent form of:

$$U = a\left[1 - \frac{b}{b + \sqrt{R}}\right]\sqrt{RI}$$

They gave to a the constant value of a = 100, and attributed to b twelve different values, increasing from 0.12 to 2.44. But they complicated this simple expression by making its coefficients depend upon the slope I; and they did this to embrace some exceptional experiments made by Humphreys and Abbot upon the Mississippi River. Their definite formula, still much used in spite of its complication, is, in metrical measures:

$$U = \frac{23 + \frac{0.00155}{I} + \frac{1}{n}}{1 + \left(23 + \frac{0.00155}{I}\right)\frac{n}{\sqrt{R}}}\sqrt{RI} \qquad (3)$$

In this n is the coefficient of roughness. By making $23 + \frac{0.00155}{I} = K$, by an easy transformation, they wrote the formula:

$$\frac{\sqrt{A}}{n} - 1 = \frac{Kn}{1 + Kn}\left(\frac{1}{\sqrt{R}} - 1\right) \qquad (4)$$

Under this form $\sqrt{A}$ becomes equal to n and independent of the slope, when R = 1 meter. The factor between parentheses changes in sign, as R is inferior or superior to one meter, and the influence of the slope upon the value of $\sqrt{A}$ changes in the same degree and is not appreciable except for excessively slight slopes.

Returning to formulas 1 and 2, in admitting the first, we distinguish* four separate classes or types of sides, as follows:

1. Sides very smooth.....$A = 0.00015\left(1 + \frac{0.03}{R}\right)$
2. Sides smooth .....$A = 0.00019\left(1 + \frac{0.07}{R}\right)$
3. Sides slightly smooth.....$A = 0.00024\left(1 + \frac{0.25}{R}\right)$
4. Sides in earth .....$A = 0.00028\left(1 + \frac{1.25}{R}\right)$

Admitting Equation 2, we would give to α the constant value 0.0115, in making β increase with the degree of roughness of the sides; from 0.0007, for very smooth sides, to 0.0150 for sides in earth.

The formula of Ganguillet and Kutter makes n vary between 0.010 and 0.025.

The comparison of the different formulas, as based upon given experiments, is graphically shown. If we take for the ordinates y the values of $\sqrt{A}$, and for the abscissas x the values of $\frac{1}{\sqrt{R}}$, the new formulas, as derived from the expression 2, would make,

$$y = 0.0115 + \beta x; \qquad (5)$$

or better still, if we designate by γ the ratio $\frac{\beta}{\alpha}$,

$$y = 0.0115\,(1 + \gamma x).$$

These would be represented by a number of straight lines all emanating from a single point (x = 0; y = 0.0115) situated on the axis of the ordinates. The inclination of these straight lines, measured by the angular coefficient 0.0115 γ, increases with the roughness of the sides. The Kutter formula for the same expression would be:

$$y = n + \frac{Kn^2}{1 + Kn}(x - 1) \qquad (6)$$

But instead of a single radiating bundle of straight lines, this expression would give for each value of n a separate bundle, departing from a variable point (x = 1; y = n). This set of bundles would be included between two straight lines corresponding to the two extreme values of I (I = OO; I = O), and having for angular coefficients, $\frac{23\,n^2}{1 + 23\,n}$ for the first, and n for the second; this last would pass through the origin. The inclination of all these lines, depending upon the term $\frac{0.00155}{I}$, increases just as I diminishes.

Not to complicate the figure given, Mr. Bazin only indicates the lines corresponding to the values I = 0.001 and 0.0001, except for the fourth type of roughness, where there has been added the very small slope I = 0.00004. The experiments referred to are represented by so many points, each having for co-ordinates the values of $\sqrt{A}$ and $\frac{1}{\sqrt{R}}$, corresponding to the particular experiment. These, however, are so numerous that the figure would become very confused if all were separately indicated; some, therefore, have been united to each other in groups, where the elements varied but little; and these are represented by a single point indicating the average of the group.

Mr. Bazin then goes on to the detail of the many experiments from which he deduces his new formula; but, as before remarked, space forbids entering into that part of his discussion.

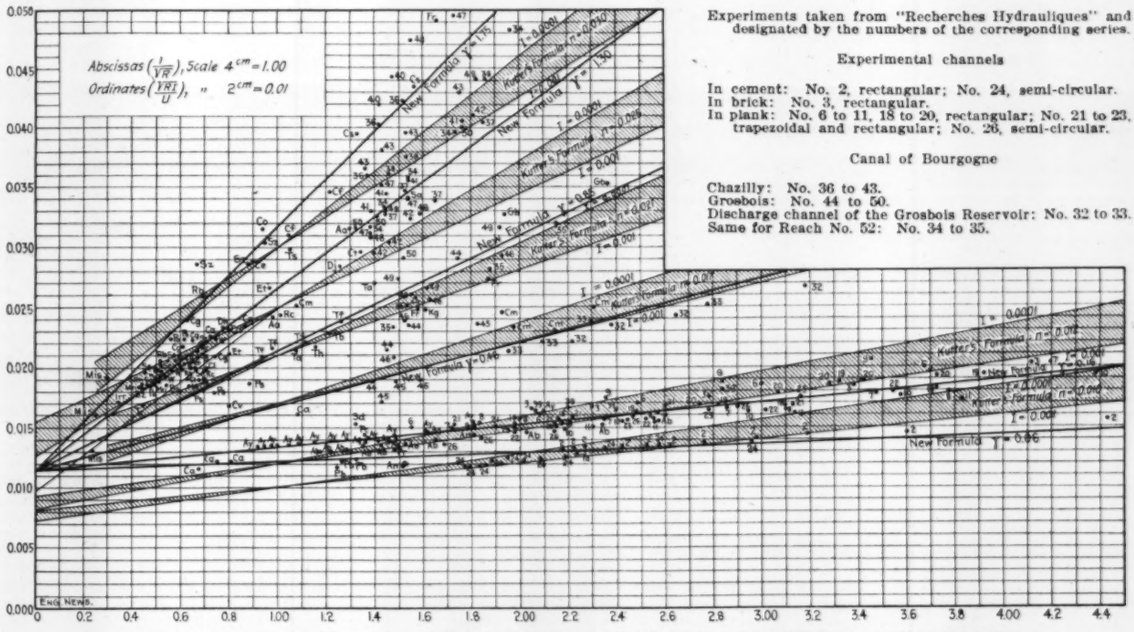

Abscissas $\left(\frac{1}{\sqrt{R}}\right)$, Scale 4 cm = 1.00
Ordinates $\left(\frac{\sqrt{RI}}{U}\right)$, " 2 cm = 0.01
New Formula
Kutter's Formula
ENG. NEWS.

DIAGRAM ILLUSTRATING NEW FORMULA FOR COMPUTING FLOW OF WATER IN OPEN CHANNELS.

Experiments taken from "Recherches Hydrauliques" and designated by the numbers of the corresponding series.

Experimental channels

In cement: No. 2, rectangular; No. 24, semi-circular.
In brick: No. 3, rectangular.
In plank: No. 6 to 11, 18 to 20, rectangular; No. 21 to 23, trapezoidal and rectangular; No. 26, semi-circular.

Canal of Bourgogne

Chazilly: No. 36 to 43.
Grosbois: No. 44 to 50.
Discharge channel of the Grosbois Reservoir: No. 32 to 33.
Same for Reach No. 52: No. 34 to 35.

Aa.—Aa.
An.—Naples Aqueduct.
Ca.—Cavour Canal.
Cg.—Ganges Canal.
Pb.—Boston Aqueduct, Charles River Bridge.
Pr.—Roquefavour Aqueduct.
Td.—Cement Pipe; Dijon.
Ab.—Boston Aqueduct.
Ag.—Glasgow Aqueduct.
Ay.—Croton Aqueduct.
Pc.—Aqueduct bridge of Crau.
Po.—Po, at Fossa d'Albero.
Ps.—Canal of Solani.
Ti.—Tiber, at Rome.
Eb.—Elbe, at Jetschen.
Fr.—Millrace at Freyberg.
Cm.—Marseilles Canal.
Cv.—Verona Canal.
Cb.—Grebenau experiment.
Ta.—Tauber.
Tb.—Beacon St. tunnel, Boston Aqueduct.
Th.—Thun Canal.
Tf.—Outlet of Lake Fucino.
Ts.—Tessien.
Cl.—Linth Canal.
Ct.—Lauteo Canal.
Dj. Dh.—Dubuat experiments.
Dj.—Canal du Jard.
Dh.—Hayne River.
Irr.—Irrawaddi.
Ro.—Rhone at Scex.
Kg.—Millrace. Kagiswyl.
Mis.—Mississippi.
Mri.—Missouri.
Rg. Rs. Rh.—Rhine at Germersheim; at Spire; in Holland.
Sa.—Saalach.
Sd.—Dorchester Bay Siphon, Boston.
Se.—Seine.
So.—Saone.
Sz.—Salzach.
W.—Weser.
Ce.—Escher Canal.
Cf.—Collector of Lake Fucino.
Co.—Chesapeake Canal.
Cs.—Simmen Canal.
Rb.—Rhine at Basle.
Rc.—Rhine near the Falls.

*"Recherches Hydrauliques," Darcy-Bazin. 1865.

A MODERN ELECTRIC CENTRAL STATION.*

By George A. Damon.

The plant of the Imperial Electric Light, Heat & Power Company, of St. Louis, Missouri, is a good example of the present tendency in electric power station practice.

The territory to be supplied with electrical energy was a down-town district, and the character of the load to be expected included arc and incandescent lighting as required in stores, hotels, office buildings, and theatres, with more than the ordinary amount of motor work for elevators and light manufacturing establishments.

In planning an installation for a commercial enterprise of this character two conditions are imposed upon the designer. First, the service supplied the customer must be absolutely reliable. The second problem is to deliver to the customer electrical energy at the least possible cost, considering interest upon first investment, maintenance, and all other factors which enter into operating expenses.

The system which has been adopted as the one best fulfilling all the conditions in this particular case, involves the use of the direct current 220-volt incandescent lamp; the location of the station as near as possible to the center of distribution; the operation of generators capable of delivering current at a potential of 500 volts, a special arrangement of the generating units, and the installation of a storage battery in the plant to act as an accumulator, and also in parallel with the generators as an equalizer. The generators are run at a potential enough greater than 440 volts to overcome the line loss, and the motor circuits are at present operated at this potential. The storage battery across the outside mains allows 220-volt incandescent lighting feeders, to be distributed over the district.

The greatly reduced investment required for copper distributing feeders for a 220-volt system from that required by the usual direct current 110-volt system, the enlargement therefore of the territory which could be supplied, as well as the better quality of light and the possibility of operating 220-volt motors on the same circuits and thus making it possible to connect in many motors all ready in use in the city, were the main advantages which led to the adoption of the 220-volt lamp. The comparative lower efficiency and higher first cost of the lamp as compared with the 110-volt type was recognized, but these points are yielding to development, and it is thought that the difference between the two lamps in respect to efficiency and price is sure to become much less as the demand for the new lamp increases.

Local conditions made the location of the plant a much simpler problem than is usually the case. To have secured free water for condensation purposes would have removed the plant much too far from the center of distribution. The difference between drayage charges on the coal delivered to the station on its present site, and the cost of bridge tolls and switching charges which would have been necessary if the coal had been delivered directly from the cars, is only 15 cents per ton in favor of the latter plan, and this is not enough to justify the extra expense in feeders which would have been required to secure the location of the plant on a railroad switch. No doubt, therefore, was entertained in regard to the advisability, in this particular case, of carrying the fuel of the plant in wagons from the railroad to the station at the center of supply, rather than transmitting the product of the plant over copper conductors the same distance.

The advantages of supplying all classes of service from one type of generator, thus simplifying the distribution circuits as well as the arrangement of the station, and at the same time increasing the economy of the plant by reducing the amount of both fuel and labor required were not forgotten. At periods of light loads it is possible to furnish the entire output for incandescent lamps, arc lights and motors from one generator, while during the hours of minimum demand the load may be carried by the accumulator.

The battery acts in the same manner in carrying the peak of the load. This peak usually extends over a period of from one to three hours, and in an ordinary plant the equipment which is necessary to supply the extra demand at this time is inoperative during the remainder of the day. The storage battery auxiliary improves the unfavorable conditions, first, by evening up the load line, and thus increasing the efficiency of the generating plant, and second, by decreasing the total amount of investment required. The advantages of convenience and reliability of an accumulator in a central station cannot be questioned.

In the generating station proper every precaution known to modern practice has been adopted to deliver at the switchboard as much as possible of the energy originally contained in the fuel.

The engine room and the boiler rooms are upon the ground level, which arrangement ensures plenty of light, good ventilation, and convenience in operation. The engine room basement is used for the storage batteries, while in the boiler room basement is located the coal storage bin, the ash-handling apparatus, the piping, pumps, hot well and condenser. A second floor is added to the building for the offices of the company, for the storage of supplies and for a machine and repair shop.

The furnaces of the boiler are of the down-draft type. Considerations of availability and cost limit the fuel supply to coal from Southern Illinois mines, which produce a bituminous slack containing about 11,000 B. T. U. per pound. As the wagons deliver the coal directly on the boiler room floor, automatic coal-handling machinery was not thought to be a good investment.

Horizontal water tube boilers were adopted on account of their quick steaming properties, the comparatively small amount of floor space occupied by large capacities, their economy of fuel, and their safety under high steam pressures, the pressure adopted for this plant being 175 lbs. In determining the size of the boilers, due allowance was made for the fact that they were to be operated in conjunction with economizers, and their capacity was reduced accordingly. The question of economizers was thoroughly considered, and they were adopted only after careful estimates had been made, which demonstrated that the probable saving of fuel effected by their use would be sufficient to cover the usual allowance for depreciation, insurance, etc., and yet leave a very good margin for interest on the investment. As no steam-driven auxiliaries are to be used in the plant, there will consequently be no other feed-water heater besides the economizer. The economizer for each battery of two 375-HP. boilers consists of 320 pipes, and the heavy weight is carried on special iron framework which places the economizer at the back and above the boilers, as shown in the figure. The flue passages and stack connections are so arranged and fitted with dampers that the flue gases can pass either directly to the stack, through the economizer to the stack, or to the mechanical draft fan in series.

A mechanical draft fan is now considered by many engineers a necessary adjunct to a power station, and especially is this true if economizers are used. Unfortunately in this particular plant the city ordinances required a stack which would carry the gases up above the surrounding buildings. For this purpose a steel chimney has been built, but it is a disadvantage rather than a benefit as far as the question of draft itself is concerned.

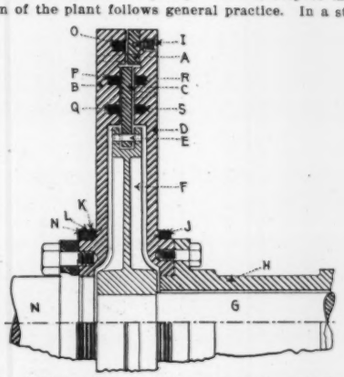
The engines are compound-condensing, and are the only steam using parts of the entire station equipment, all auxiliary apparatus being operated by means of electric motors. The steam thus passes directly from the boilers into the engines with a minimum amount of steam piping exposed for radiation losses. The steam from the engines exhausts into a surface condenser placed in the basement below the boiler room, from which, when condensed, it is pumped into the hot-well and through the economizers back into the boilers.

The condensing water is taken from the bottom of a cooling tower located upon the roof at an elevation of 50 ft. above the condensing apparatus. After this water passes through the condenser it is forced back to the top of the cooling tower by means of centrifugal circulating pumps. The water circuit is arranged so that the weight of the descending column is used to balance the weight of the ascending column of water. The work actually required of the circulating pump, therefore, is represented by the amount of power required to raise the water through the height of the tower, or about 30 ft., and the net result is the same as if the tower had been located on the ground level.

The plans for the completed station contemplate a total capacity of 5,000 K-W. There are at present, however, installed in the station but two engines, one of 750 HP. and the other of 1,500 HP. capacity. These engines are of the cross-compound marine type, of massive design, and run at a speed of 150 r. p. m. They are expected to develop an indicated horse-power hour on less than 14 lbs. of water per hour. Each engine is designed, however, to stand a continuous overload of 100%. This will be developed by means of admitting high pressure steam directly into the low pressure cylinder. The conditions under which it is expected to operate the engines in this manner will be referred to later. The cylinders are placed side by side, each piston acting upon a separate crank. Between the cylinders is located the receiver, which is provided with copper reheating coils. The high pressure cylinder is steam-jacketed on the barrel, and both cylinders have a steam-jacket on the heads. Both receivers and cylinders are protected with a non-conducting covering. Each engine is provided with a heavy flywheel located in the center of the frame between the cylinders. The speed is regulated by a shaft-governor operating an eccentric connected to the cut-off valves of the high-pressure cylinder, and in addition to this governor, each engine is provided with an additional automatic safety-valve, designed for the protection of the engine in case the speed should be abnormally increased for any reason. The engines also have a speeding device attachment by means of which they may be brought to the same rate of speed under frictional load as under full load.

The engines are directly connected to three 500-K-W. generators and two 50-K-W. boosters. These dynamos are of the multipolar type with ironclad bar wound armatures. Provision is made for sliding the field casting parallel with the shaft a sufficient distance to allow the field coils to be removed and the armatures reached for repairs. The brush holders are carried in a circular iron frame, arranged to be moved by means of a threaded rod and a hand wheel, so that the position of the brushes may be adjusted. An additional hand-wheel is provided for lifting the brushes from the commutator.

The engines and generators are connected by means of the "Arnold System." This system of power station design is well known, but its application to this particular station will be of interest. The general idea of the system is to improve upon the usual direct-connected unit principle by mounting each generator in such a manner that it can be operated by more than one engine. The line of engines and generators as they will eventually appear as the output of the station is increased contains three engines, the capacity of the center engine being 1,500 HP. and double that of either end engine. Each of the four large generators, two on each side of the center engine, is rated at 500 K-W., while each of the small central dynamos, located between the larger machines, is a low-voltage booster of 50 K-W. capacity. The central engine therefore has a capacity sufficient to operate two of the generators when running at its most economical load, while either end engine is proportioned to supply but one generator with power under normal working conditions. The use of the boosters in this plant is incidental, and occurs at periods of light loads only, so that no additional engine capacity over that demanded by the main generators is required for their operation. Under all ordinary running conditions the units of this plant are manipulated as usual, an effort being made to vary with the load the number of engines running, so as to keep those in operation at any one time working as nearly as possible at their rated capacity. In this respect the operation of the plant follows general practice. In a station



Detail of Magnetic Clutch used in Arnold System of Connecting Engines and Generators in Power Station of the Imperial Electric Light, Heat and Power Co., St. Louis, Mo.

containing independently-direct-connected units, however, if any piece of the generating machinery gets out of order, it disables the entire unit and thus the commonly accepted principle which underlies the selection of the size and number of units for a direct-connected station is to have in reserve and always ready to be put into immediate service, engine and generator capacity sufficient to take the place of the largest single unit in operation. Thus, with a station containing five generating units of equal size, the station capacity which may be safely relied upon is the combined output of but four of the units, the fifth unit being either held in reserve or undergoing repairs. An additional investment of 25% in station equipment over that actually required by the demands of the service is necessary, therefore, in this case, in order to ensure reliability. One of the advantages of the Arnold system of power-station construction is that the extra reserve unit is not required. Each generator is not rigidly connected to its corresponding engine but is in such a manner that it may be operated by more than one prime mover. Thus the central engine may run either one or all four of the generators as well as the two boosters, while the smaller end engines can reach either or both of two generators and also one booster.

In the method of mounting and connecting the dynamos which makes this flexible arrangement possible each generator armature is mounted on a hollow shaft or quill, which is carried independently in its own bearings. The booster armature is attached to the solid shaft. This shaft is made of forged steel and extends through the hollow generator quills, but without touching them. It is by means of this shaft that any engine can reach the generators not contiguous to it; but under all normal operating conditions, this shaft does not turn, so that this system of connecting involves no more friction and requires no more lubrication than the ordinary arrangement. The coupling on the end of the shaft permits of three combinations: The engine may be directly connected with the quill of the adjacent generator, allowing the interior shaft to remain idle, or the solid shaft may be attached to either the engine flange or to the generator quill. The latter two combinations allow the transfer of power peculiar to this system.

The coupling or clutch is of particular interest, as it is said to be the first magnetic clutch applied upon a large

*Condensed from a paper presented at the 15th general meeting of the American Institute of Electrical Engineers, Omaha, June 30, 1898.

scale to power station work. The accompanying cut shows a cross-section detail of this clutch. One part, B, is bolted to the engine flange, N. A corresponding part, D, is bolted to the generator quill, and this part carries an annular armature, A. Radial arms F, keyed to the solid shaft G, carry an interior armacure C. Each coupling is provided with five circular coils of magnet wire O, P, Q, R and S. These coils are electrically connected to contact rings J, K and L, carried on insulating bushes bolted to the hubs of the clutch. Stationary brushes which are connected through a system of switches to the storage battery 'bus bars make it possible to send a current around any coil. The parts of the clutch containing the coils are made of cast-steel of high permeability, so that when a current is sent around any coil, the surrounding metal becomes a magnet and the armature facing the coil is immediately magnetically attracted. The two surfaces of the clutch parts being held in contact by a pressure of at least 80 lbs. per sq. in., it becomes possible to transmit power from one to the other. Thus to connect engine shaft N to generator quill H, a current is sent through coil O in that part of the clutch B attached to the engine shaft. Armature A, which is attached by means of strong studs to that part of the clutch which is securely bolted to the generator quill, is immediately attracted, and overcoming the small resistance of the spring I, the two parts become firmly attached to each other, making it possible to run the generator from the engine. If it is desired to revolve the interior shaft by means of the engine, the current is sent through coils P and Q in parallel, attracting armature C, while if the solid shaft is being turned by the other engine and it is desired to connect the shaft to the generator quill, then the coils R and S are energized and the armature C is attracted in the other direction. The circuits to these coils are all controlled by means of switches on the main switchboard. These switches are so arranged that when the circuit of any coil is broken, the discharge of the extra current is taken up through a carbon resistance, and the insulation of the coil is therefore protected from the liability to puncture. When the current in any coil is discontinued, spiral springs have been provided to overcome the residual magnetism and bring the armature back to its original position.

If both parts of the clutch which are to be attached are stationary, the connection becomes an easy matter, but if one part is revolving, it becomes necessary to put the other part in motion before the current is sent through the coils. This is accomplished by starting the dynamos as motors and bringing them up to speed before closing the magnet coil switch. For this purpose, regular starting-boxes have been installed, one for the boosters and the other for the generators, so that any machine may be thrown into or out of service directly from the switchboard. The result of the whole arrangement is, that a number of combinations between the engines and the generators becomes possible. Under all normal running conditions, the center engine will run its two adjacent generators, and the outside engines will operate the end generators. Each booster may be run when necessary, from either of two engines. The entire line of machinery may be connected together, so that all the engines and generators operate in unison as one large unit, the speeding attachment on the engines making it possible to operate them satisfactorily in this manner.

In case of accident to any generator that particular machine may be stopped without stopping its corresponding engine, and the electrical load will be immediately taken up by the other generators, but without overloading the engines. In case of accident to any engine, the ability of the other engines to carry an overload of 100% may be taken advantage of, if necessary, without overloading any of the generators. Thus the center engine is capable of carrying all four of the generators fully loaded, while the smaller end engines can operate two of the generators, if necessary, in case of a breakdown of the larger engine. The plant may, therefore, operate at period of maximum load, at its full rated capacity, depending entirely upon the advantages of the system of arrangement for a reserve in case of a breakdown to any part of the equipment.

All the variable speed motors operating the auxiliary equipment of the plant are designed to run at two voltages, the maximum being 440 volts, and the other voltage being one-half the maximum. Further speed regulation is obtained by changing the field excitation by means of a small resistance in the field circuits. The use of armature resistance is thus entirely obviated. A switchboard containing the switches and controling apparatus for the pumps and fan motors has been placed conveniently in the boiler-room and another auxiliary board has been placed in the engine-room to control the circulating pump and cooling-tower motors as well as the circuit leading to the crane which spans the engine-room. The use of economically controlled electric motors for running the pumps, fans and other auxiliaries of the plant is expected to result in a considerable saving of fuel.

The storage battery is located in the basement and has a capacity of 2,000 ampere-hours at the normal rate of discharge, but is capable of standing a discharge at the rate of 500-KW. for one hour. The station, therefore, as it now stands, can carry a maximum of 2,000-K-W., three-quarters of which can be taken care of by the generators, and the remaining quarter supplied by the battery. The battery consists of 280 cells, 100 of which are end or regulating cells, by means of which the potential may be regulated, the voltage depending, of course, upon the number of cells in circuit.

No radical departure is claimed for the design of this station. It has been described simply to show the latest solution worked out by conservative engineers of the problem of the generation and distribution of electrical energy. It is thought to be of interest because it presents a combination of the following widely discussed features of modern central station practice: (1) Improved furnaces; (2) Water-tube boilers; (3) Mechanical draft; (4) Fuel economizers; (5) Electrically-driven auxiliaries; (6) Cooling tower condensing system; (7) Arnold system of power station construction; (8) Battery auxiliary; (9) Two-wire distributing system, and (10) 220-volt lamps.

A STEAM ENGINE WITH OSCILLATING PISTON.

The engine illustrated herewith is somewhat of a novelty in steam engine design, and occupies a position midway between the ordinary reciprocating engine and the rotary engine. The cylinder has its axis parallel with that of the flywheel shaft, and in one end is the steam chest. The cylinder proper is divided into two compartments

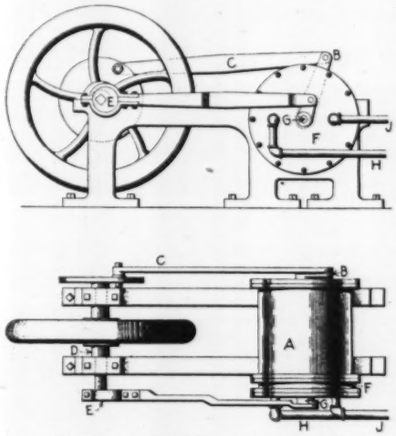


Fig. 1.—Elevation and Plan of Engine with Oscillating Piston.
Benjamin H. Trucks, Inventor.

by a partition which is split along the middle to make room for the piston shaft. On this shaft are two pistons or wings which oscillate in the compartments, and on the end of the shaft is an arm carrying the connecting rod, no crosshead or guides being required.

Fig. 1 is a side elevation and plan of the engine, in which A is the cylinder, B a vertical oscillating arm on the piston shaft, which passes through the axis of the cylinder; C is a connecting rod which is attached to B and drives a crank disk on the flywheel shaft D. On the other end of this latter shaft is an eccentric, E, whose rod drives

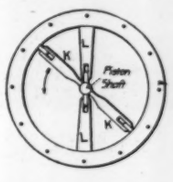


Fig. 2.

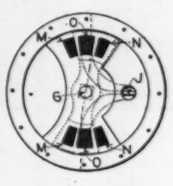


Fig. 3.

Fig. 4.

Fig. 2.—End Elevation of Cylinder, with Cover Removed.
Fig. 3.—End Elevation of Steam Chest, with Cover Removed.
Fig. 4.—Oscillating Bar Carrying Slide Valves.

the oscillating valve in the steam chest F, this valve being carried to the stub shaft G, which is independent of the piston shaft. The steam pipe is shown at H, and the exhaust pipe at J.
its cover removed, showing the reciprocating pis-

Fig. 2 is an end elevation of the cylinder with ton K and the fixed partitions L, the inner ends of which are fitted with packing which bears against the piston shaft. Fig. 3 is an end elevation of the steam chest with its cover removed. In this view, M and M are the steam ports, and N, N the exhaust ports, while O, O are the exhaust passages leading to the exhaust pipe at J. Over these ports move two slide valves, P, P, Fig. 4, carried on the ends of a rocking bar Q, which is mounted on the stub shaft G. These valves have openings through which the exhaust steam from the cylinder passes to the passages O. In Fig. 4 only one of the valves is shown in position, in order to show the corresponding opening in the bar.

This engine is the invention of Mr. Benjamin H. Trucks, of Caldwell, Kan., who has had several built by P. I. Harris, of Wichita, Kan.; the L. P. Lester Machine Shop, at Newton, Kan., and the Ersham Machine Co., of Enterprise, Kan. The smallest, built merely as a working model, is of 2 HP., with cylinder 4 ins. diameter and 3 ins. long, the weight of the machine being only 68 lbs. The largest engine is of 15 HP., with a cylinder 8 ins. diameter and 6 ins. long, the piston area being 30 sq. ins. This engine weighs 750 lbs., and occupies a space only 24 × 44 ins. One of the larger engines is now at work driving the plant of the Enterprise Laundry, at Joplin, Mo., and has been in regular service since Feb. 23, 1897. The advantages claimed for this type of engine include reduction in friction and in number of parts, economy in steam consumption, and small floor space

THE INCREASE IN THE WORLD'S PRINCIPAL NAVIES.

Among the late reports of the Office of Naval Intelligence, in the U. S. Navy Department, is one by Lieut.-Commander W. H. Driggs, U. S. N., on "The Increase in Naval Strength" of England, France, Germany, Russia and Japan. At a time when additions to our own navy are being looked upon with especial favor it is interesting to note what other nations are doing in this direction, and for this reason we make a brief abstract of the paper of Lieut.-Commander Driggs.

England, as always in naval matters, is far in the lead. The budget voted for 1897-98 amounts to about $107,000,000, providing for an expansion in all branches of the navy. The number of officers and men has been increased from 88,850 in 1895 to 100,000 in 1897, including in these figures the coast guard. The total of ships under construction and to be built during the fiscal year of 1897-98 is 108, including 14 battleships, 8 first-class cruisers, 9 second-class cruisers, 10 third-class cruisers and 52 torpedo boat destroyers.

Russia is not only adding to her naval strength but is also actively engaged in opening up harbors and channels for strategical purposes and establishing naval bases in foreign countries. The naval program that was mapped out in 1896 involves an expenditure of $318,000,000, though the exact number of ships contemplated is not specified by Lieut.-Commander Driggs.

France in her budget for 1898 asks for $55,108,000 for naval purposes, allotting nearly $20,000,000 of this for new ships. Her present building program extends over a period of eight years, and involves an expenditure of about $144,300,000. Like Russia, she is providing for better harbors and channels at home, and is creating bases for supply and repair in foreign waters. Admiral Besnard, the French Minister of Marine, calls especial attention to the need of fast cruisers in modern naval warfare, and to emphasize his demand for additional ships of that class in the French navy he presents two tables showing certain naval conditions in May, 1897, as follows:

Available.	England.	Triple alliance.	Russia.	France.
First-class cruisers	24	3	5	8
Second-class cruisers	61	26	7	12
Dispatch boats	50	19	20	13
Torpedo-boats and torpedo-boat destroyers.	51	38	9	13
Total	195	86	41	46
Under construction.				
First-class cruisers	12	10	6	5
Second-class cruisers	6	3	1	7
Dispatch boats	10	5	0	1
Torpedo-boats and torpedo-boat destroyers.	14	1	1	3
Total	42	19	8	16

In addition to the above France had in 1897 10 battleships and 7 armored cruisers under construction, and, counting all classes, she had 63 war ships under construction in that year.

Germany is now putting into execution a naval

program laid down in 1873 and deferred until the present time for lack of funds. This program calls for an active fleet of 17 battleships, 8 armored coast-defense ships, 9 large cruisers and 26 smaller cruisers. In addition, she proposes a reserve fleet of 2 battleships, 3 large cruisers and 4 small cruisers. The total proposed and those classed as available by the German government are shown in the following table:

	Total authorized.	Available.
Battleships	19	12
Armored coast defense	8	8
Large cruisers	12	10
Small cruisers	30	23

Germany recognizes the fact that to maintain a modern fleet she must provide for the replacement of old-type ships. To this end she fixes the period of efficiency of battleships and armored coast-defense ships at 25 years, of large cruisers at 20 years and of small cruisers at 15 years; after these periods of service they would have to be replaced by others of the newest type. The personnel of the German navy is to be raised from 18,138, its present strength, to 26,637 in 1904.

Japan has a naval program to be completed in 1906, and during this period she proposes to spend $132,396,546. This program calls for the addition to her navy of the following vessels: Four battleships of 15,000 tons, 4 armored cruisers of 9,500 tons, 3 second-class protected cruisers of 4,800 tons, 2 third-class protected cruisers of 3,200 tons, 3 torpedo gunboats of 1,200 tons, 11 torpedo boat destroyers and 89 torpedo boats. Prior to her war with China Japan only had 18 cruisers ranging from 1,500 to 4,000 tons. When those authorized are completed she will have a navy of 65 ships of war, 11 torpedo boat destroyers and 115 torpedo boats. Japan now has 1,725 officers in her navy exclusive of midshipmen and sub-lieutenants.

In the above lists the total proposed expenditure for naval purposes, according to adopted programs, amounts to $1,001,690,000, all to be expended before 1906 by five nations only.

TEST OF A PIPE DISTRIBUTION SYSTEM.*

By James S. Haring, M. Am. Soc. C. E.†

In testing the distribution system of a water-works recently designed and constructed by the writer, some peculiar facts were developed which have not as yet been satisfactorily explained.

In 1896 a new system of pipes, ranging in size from 12 to 4 ins., and in length about 10½ miles, were constructed. The work of laying the pipes began in May, and was completed in the following December. At the time the work was progressing provision was made for placing hydrants, but they were not then contracted for, and their T-connections were closed by a temporary plug, as were also some dead ends.

The pipe contract was awarded to one of our most reliable pipe companies. The specifications were the usual provisions for a test of 300 lbs. hydraulic pressure per sq.in., and to be sharply rapped with a hammer while under such pressure. No inspector was placed at the foundry, the pipe being taken under the company's guaranty. We had an inspector examine the pipe while being unloaded and again go over the pipe after being hauled to its position on the street; finally, it was inspected by the contractor's men when being laid. The same course was pursued with regard to the manufacture of the valves, each valve being tested at the factory to 300 lbs. internal pressure, the contract for which was also given to one of the largest manufacturers. About 175 valves were used in the mains, and 70 in setting hydrants as supplemental valves.

The contracts for laying the pipe and setting the hydrants had specified that a test of 200 lbs. per sq. in. should be made.

The territory covered was that of a side hill ranging in elevations from 0 to 250 ft., the reservoir being at an elevation of 352 ft. A temporary connection was made between the main leading from the reservoir and the system tested by means of a 2½-in. fire hose connected with a hydrant nozzle.

The test was under the charge of a foreman who had been an inspector on the pipe laying and hydrant setting, a man of more than ordinary intelligence, carefulness, and honesty in the performance of his work, and a man who had also been for a number of years a foreman in one of the largest foundries doing fine metal work, in the East. This inspector not only brought experience, but energy and trustworthiness to bear in the performance of his duties, and when he reached a conclusion it was reliable and could be depended upon.

The pipes were filled with great care; about two weeks were taken to accomplish this so that no hammer or compressed air would occur. Each hydrant was opened and left open to allow the escape of air as it was found the water was rising to near its level, until it ran out of the hydrant; blowoffs were opened and all dirt and accumulations gotten out of the pipes until we were satisfied that every precaution had been taken to make a proper test.

The means of testing were those usually employed, a boiler feed pump set in a galvanized sheet-iron 10-gallon can bolted through the bottom to a plank, the pump connected with an inch galvanized iron pipe and valve by a union to a special hydrant nozzle cap. Water was supplied to the can from a barrel filled from the hydrant before connecting the pump. Attached to the other hydrant nozzle was a test gage registering up to 200 lbs. pressure (this was afterwards changed to a gage registering up to 400 lbs., for the peculiar reason that the contractor who set the hydrants claimed that we were going over 200 lbs. in our test, and were thereby causing the various leaks which appeared in his work, and were violating the terms of his contract by excessive pressures); the sensitiveness of this gage was not very delicate and caused us some annoyance.

The test was begun at the bottom in small sections and from this proceeded slowly over the whole system. There being no service connections, the work was very much simplified. First the reservoir test was made by shutting off all supply; the pressure was noted for a few minutes, when the pump would be applied and a pressure maintained by closing the globe valve from the pump. All defects were sought for and corrected in each section as found.

The very liberal use of valves in the system made it possible to cut off small sections and to locate defective valves, the defect consisting generally of some obstructions under the disk. The writer at the beginning found considerable trouble on one section; the action of the gage convinced him it was not a leak, but must be a defective valve; after manipulating numerous valves, he located the trouble on one immediately at the corner where the test was being made. After digging up the valve and taking off the dome fully a pound of gravel, sand and part of a tin can were found in it.

We were able to make the hydrant test separately because of the supplemental valve with all but two joints, and the hydrant itself separated from its connection. The hydrant was the first test, then the whole to the valve, and finally the pipe section with such enlargement of it as was desired, or found advisable.

As a charge was to be made against the various contractors doing the work of furnishing materials, each was notified of the test to be made and the date when it would begin. Only the contractor who set the hydrants, a local man, responded.

The test demonstrated only nine minor defects in pipe laying, the cost of repairing which amounted to $89.39. But the pipe demonstrated the peculiarities of the situation, and it in turn was surpassed by the strange defects found in the valves. Three breaks occurred in the 12-in. pipe, two in the 8-in. pipe, and two in the 6-in. pipe, the cost to repair which amounted to $237.49. The fracture in this pipe was, in every instance, shown by the pipe to be inherent foundry defects, cold shorts, honeycombed shrinkage, and foundry imperfections.

After the foundry test, after the care of inspection and every precaution, why should these pipe fail under a 200-lb. pressure test?

Now as regards the valves. The writer required in the valves supplied for the mains the use of sheet rubber gaskets, but in the hydrant valves that provision was not made, and the ordinary oiled paper was used for gaskets. Of the 175 valves used in the mains, 19 were found to be leaking around the packing gland gasket; of the 67 hydrant valves then placed, 13 gaskets were defective, the total cost of making good the defects being $152.33.

What caused these leaks is one of the excuses for bringing this paper to your attention. Our claim is that the general cause was that the gaskets were too thin, that the iron surfaces were compressed together without sufficient elastic material to shut off fully the space between their faces and also that in two instances the follower of the packing gland was too large to enter the casting.

The valve manufacturers made a careful examination of our claims, and disputed their liability for the damage, and they claimed:

(1) That we had not properly conducted the test, having compressed air in the system which had found its way out through the gaskets of the valves as the points of least resistance.

(2) That if the air had not been compressed in the system, it had been in the domes of the valves, thereby causing the gaskets to blow out, and that the air pressure would amount under such conditions to more than 200 lbs.

(3) It was claimed that the packing gland nuts had been tightened up when they were inspected in May, 1896, and that the gaskets had shrunken so that the nuts again needed tightening.

When we produced the gaskets, in each case tagged as to locality, and found none of them showing the least signs of having been blown out, no explanation made by them seemed to account for the cause.

That the leaks were very large from this cause, we demonstrated to the personal examination of a representative of the company who happened to be present when one of the leaks made itself evident.

It is claimed by the makers of these valves that no similar experience has ever come to them in a matter of this kind; of the many thousand of valves sent out by them none have ever been found defective in the two ways discovered in this case. They claim that with their shop practice and system of testing valves, that no such defects could be afterwards found; yet they were, and they are indisputable.

*Abstract of a paper prepared for the Buffalo meeting of the American Water-Works Association, June, 1898. Owing to the inability of the author to be present, the paper was not read, but it was ordered printed in the proceedings.

†Engineer of Water Commissioners, Nyack, N. Y.

THE ERECTION OF A BRIDGE OVER THE NORTH RAILWAY IN PARIS.

Owing to increased traffic across the sunken tracks of the Chemin de fer du Nord, in the XVIII. Arrondissement of Paris, the railway company was lately required to construct another bridge for street traffic at this point. The method of erecting, or rather of launching this bridge over the eight or ten tracks of the railway has been described by "Le Genie Civil," and from this description the following abstract is made:

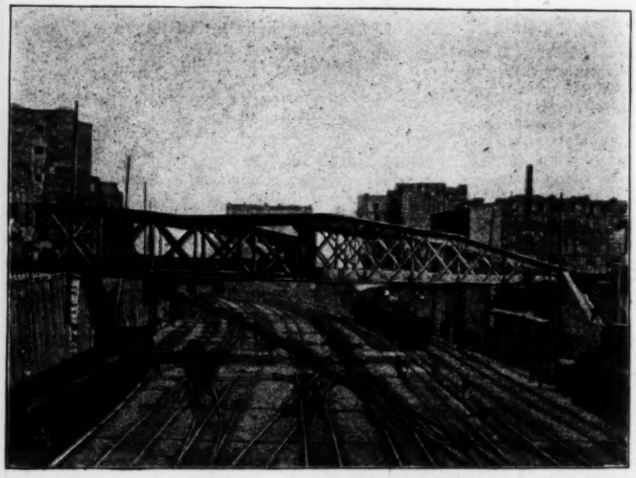


FIG. 1.—THE ERECTION OF A BRIDGE OVER THE NORTH RY., PARIS; VIEW OF OPENING SPANNED BY MAIN AND PILOT TRUSSES.

The mean span between the faces of the bridge abutments was 132 ft.; the bridge floor was on a slight grade and the minimum free height above the tracks was 17 ft. The bridge itself was a riveted bow-string truss, 50.84 ft. wide between centers of trusses, and tied together by cross-girders spaced 13.74 ft. apart. The floor was made of longitudinal beams and buckle plates, supporting two footways of 10 ft. each, and the roadway proper 29.52 ft. wide. This floor was paved with wood upon a beton base and the footways were covered with a coating of asphalt ¾-in. thick. The metallic part of the bridge in place weighed 995,720 lbs. and cost erected $47,085, or not quite 5 cts. per lb.

Owing to the traffic upon the tracks beneath, and their peculiar arrangement, it was deemed impracticable to erect this bridge upon the usual timber falseworks; and the engineers of the railway company decided to erect the bridge upon the ground, at one side of the opening, and then to move the whole structure forward to its destined position. As it was a single-span bridge it became necessary to provide the bridge with an advance or pilot truss. This pilot had a total length of 87.94 ft., and it weighed 110,000 lbs. Acting as a concentrated load, this weight centered at a point 36 ft. beyond the point of connection of the two trusses. The extreme forward

end of the pilot truss was slightly curved upwards to permit the truss to more easily slide upon the forward rollers. The pilot truss was constructed with a slight grade, designed to compensate for the general deflection during the operation of launching. The two trusses were connected by riveting together the abutting end members and by struts extending back upon and riveted to the upper chords of the bridge proper, as shown in the illustrations; the bottom of the joint between the two bridges was covered by steel plates. The two main trusses of the pilot were firmly united by a system of horizontal and vertical bracing.

The bridge proper was erected in such a position that the pilot truss could be built and attached to it, with the nose of the pilot resting upon rollers

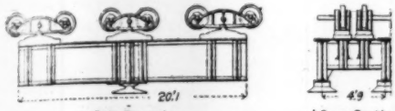


Fig. 2.—Roller Supports Used in Erection of a Bridge.

on the near abutment. These rollers were 23.58 ins. diameter, made of cast steel, and they were arranged in four groups of six rollers each under each truss, on the launching side of the opening, and one group of four rollers under each truss on the far side of the opening. These rollers rested in pivoted supports of cast steel, carried by balance beams supported in turn by "Belleville" or pivot washers on beams on the ground. All of these rollers were so placed that the lower chord of the bridge was upon a uniform down grade of 63.4 ft. per mile. The actual grade of the bridge in position was 126.7 ft. per mile, or twice this grade; but the reduction was made for the purpose of greater safety in launching.

The bridge was moved forward upon the rollers by two windlasses, placed behind the bridge and each operated by eight men. From the drums of these windlasses two chains passed under the bridge, over pulleys attached to the farther abutment, and then back over two other pulleys attached to the rear of the bridge, with the ends of the chains fixed to the nearest abutment.

After every detail of the proposed operation had been carefully tested, the launch was made in two days, Aug. 23 and 24,. On the first day work was commenced at 9 a. m., and it was stopped, according to the program arranged, as soon as the pilot-truss had entirely cleared the rollers on the near abutment. The launching was resumed at 7 a. m. the next morning, and the truss proper was rolled across the opening by 11 o'clock, without interruption of traffic on the railway or trouble of any kind.

In place for launching the total weight of the bridge was 877,800 lbs., on a length of 143.9 ft. The total length of the pilot truss was 87.94 ft. and it weighed 110,000 lbs. As a result, the uniform distributed load of the main truss was 6,100 lbs. per lin. ft. and that of the pilot truss 1,251 lbs. per lin. ft. The work was done from the plans and under the direction of M. Boreux, Chief Engineer of Public Ways and Lighting, of Paris.

The actual cost of this pilot-truss and its manipulation is not stated in the article in "Le Genie Civil," nor does the author say what was finally done with this expensive and seemingly wasted material. It is safe to say that an American engineer, with a problem of this kind on his hands, would have made use of timber which can be used again. With eight or ten tracks at his disposal, one or more could certainly have been thrown out of service long enough to build a central wooden tower or pier; and this tower could have been utilized as a midway roller support for the pushing out of the counter-weighted main truss. Or, the same tower could be used for erecting two 70-ft. temporary wooden spans, upon which the bridge proper could either have been erected or rolled out complete. If headroom were lacking, the main bridge could have been built above grade and lowered into place upon the abutments.

THE COST OF PRODUCING POWER AT THE LACHINE RAPIDS ELECTRIC POWER PLANT.

The Lachine Rapids power plant, a full description of which was given in our issue of Feb. 18, 1897, has now been in operation about eight months, although all of the turbines and electrical generators have not as yet been installed. This plant, it will be recalled, utilizes a portion of the water power of the Lachine Rapids of the St. Lawrence River about 7 miles above Montreal. The rapids proper are about 5 miles long, with a fall of 30 ft. The Lachine Rapids Hydraulic & Land Co. built a dam about one mile from the foot of the rapids and a dike parallel with the bank and some 5,000 ft. long, which together give the company about 15,000 cu. ft. of water per second with a head of 11 ft.

Taking the plant as it now exists and as it is at present operated, Mr. W. McLea Walbank, managing director of the company, deduces some interesting figures which he presented in a paper read before the National Electric Light Association at its convention held at Chicago in June. The cost of distributing power is not considered since it would be the same no matter how the current was generated, and the figures given consider only the cost of generation and transmission to the sub-stations in Montreal.

The cost of all water rights, dams, wing walls, power houses, hydraulics and electric generating and transmitting machinery installed to the present time amounts to $957,200. This includes a power house, dams, etc., sufficient for the maximum output (about 14,500 HP.), although the present hydraulic machinery and generating apparatus has a capacity of only 4,000 K-W. at the generator switch-board. Allowing a loss of 10% for transmission, the present generator plant can deliver at the sub-station for customers' use 3,600 K-W., and taking the investment at $957,200, this corresponds to a first cost of $263.83 per kilo-watt.

To determine the total cost per kilo-watt an estimate is made as follows:

Interest on $263.83 at 6%, per K-W.	$15.95
Depreciation, 5% on $300,000 (taken as the value of that portion of the plant of 3,600 K-W. subject to depreciation), = $15,000, or per K-W.	4.17
Operating expenses, including labor, repairs, insurance, etc., for 3,600 K-W., per K-W.	2.85
	$22.97

This gives a total cost of $22.97 per K-W. per year for continuous service.

Considering the plant completed and all machinery installed as planned, there will be 72 turbines in operation, and the plant will represent an investment of $1,113,273. At that time the output after deducting all losses will be 13,500 K-W. delivered at the sub-station, and the investment per kilo-watt of such output will be $82.46. As in the former case:

Interest on $82.46 at 6%, per K-W.	$4.95
Depreciation at 5% on the increased value of depreciable property but distributed over 13,500 K-W., per K-W.	1.68
Operating expenses, also increased but now spread over 13,500 K-W., per K-W.	1.51
	$8.14

On this basis the cost per K-W. per year for continuous service will be only a trifle more than one-third of what it is at present.

If the above figures for the cost of power are compared with the cost of steam power at Montreal, where steam coal costs about $3.50 per ton, it will be seen that the company can market its power at a good profit and still make a large saving to its customers over the cost of power or electric current produced by steam.

THE RECLAMATION OF THE SAND-DUNE territory of the Pacific Coast, at Golden Gate Park, near San Francisco, is carried on as follows: The shifting sand is first seeded with sand-grass (Arundo arenaria) and this is allowed to grow for two years; by this time the ground is sufficiently held in place to permit the planting of the Monterey Pine and Cypress, and these trees, in two or three years, complete the reclamation. The entire cost of reclamation does not exceed $50 per acre, and out of the 1,040 acres in the park, 500 acres are now planted with the pines.

A LARGE FLEXIBLE WOVEN SUCTION HOSE, for a centrifugal pump dredge, has been made by George Angus & Co., of Newcastle-on-Tyne, for use in the dredging of sand bars by the Natal government. The pipe is 42 ins. diameter and 10 ft. long, and is made of 1-in. best yacht Manila rope, extra soft laid. To keep the tube in shape iron hoops, 1½ ins. diameter, were woven into the circumference at intervals of less than 1 ft. The same firm has just shipped a similar suction pipe to East London, Cape Colony. This latter pipe is 27 ins. diameter, with 1⅛-in. hoops 30½ ins. apart at the top and 8 ins. at the bottom of the pipe, and the pipe was 9 ft. 8 ins. long and woven on a curve of 10 ft. radius.

MEASUREMENTS OF STREAM FLOW in California in 1897 gave the following main results:

River.	Daily flow, sec.-ft.* Maximum.	Minimum.	Mean.	Total, for year, acre-ft.*
Sacramento[1]	89,100	4,000.0	12,482.0	8,912,617
Stanislaus[2]	10,280	140.0	1,855.0	1,319,333
Tuolumne[3]	14,700	28.0	3,364.0	2,422,827
San Joaquin[4]	18,600	60.0	3,105.0	2,248,979
Kings[5]	22,732	250.0	2,933.0	2,129,964
Kings[6]	18,900	208.0	2,115.0	1,533,288
Kern[7]	5,342	260.0	1,234.0	894,057
Little Rock Creek[8]	308	0.2	25.0	17,979
San Gabriel[9]	1,765	18.0	130.4	93,169
Santa Ana[10]	585	29.0	86.6	61,524

Gaging Stations: [1]Red Bluff, [2]Oakdale, [3]La Grange, [4]Herndon, [5]Red Mountain, [6]Kingsburg, [7]Bakersfield, [8]Palmdale, [9]Azusa, [10]Warm Spring.

*1 sec.-ft. equals 50 California's miner's-inches. 1 acre-ft. is the amount necessary to cover one acre 1 ft. deep, or 43,560 cu. ft.

The measurements were made by the United States Geological Survey, of which Mr. Chas. D. Walcott is director. We are indebted for this information to Mr. J. B. Lippincott, Resident Hydrographer for California, 412 Byrne Building, Los Angeles, Cal.

THE CARR AUTOMATIC MACHINE GUN, invented by Howard Carr, of San Francisco, was lately tested in that city. The gun is fired from a tripod and weighs 20½ lbs. complete. It uses the Krag-Jorgensen cartridge and is fed by a detachable magazine containing 310 cartridges and weighing about 25 lbs. The gun itself is described as "an ordinary Krag-Jorgensen barrel, automatic breech-action, with pistol-grip." In the test noted it was used as a single shot, and then with the continuous fire at the rate of 600 shots per minute. The San Francisco Arms Co. control the patents.

A NEW ENGLISH SERVICE BULLET has been adopted and will be first used in the Egyptian campaign now in progress. This bullet is the same in general form as the Lee-Metford bullet; .303-in. diameter, 1½-in. long and weighing 215 grains; it thus fits all the service rifles and machine guns. The case is nickel, with the lead filling the base only and leaving the conical end empty. When this bullet strikes, the conical end burrs and opens backward, lessening the penetration and increasing the shock. Cordite is used for propelling it, and while it is only half the weight of the old Martini-Henry bullet of 410 grains, it has as much energy as the latter with the old service charge of powder. The new bullet is being made at the Woolwich Arsenal at the rate of 2,000,000 rounds per week. If it proves satisfactory in the Khartoum expedition, a permanent stock will be kept on hand at Woolwich.

THE TRANS-SIBERIAN RAILWAY, according to U. S. Consul Smith, of Moscow, has cost, in the five years, 1893 to 1897, inclusive, $188,014,938. In addition to the above, $5,978,663 has been spent for topographical and astronomical work, irrigation, surveys, geological study, agricultural instruments, etc., connected with the development of the country adjacent to the railway.

WESTINGHOUSE AIR-BRAKES, in value ranging from $2,000,000 to $3,000,000, have been ordered by the Russian government for the Manchurian Railway; and there is a prospect of this contract being doubled in the near future, according to U. S. Ambassador Hitchcock, of St. Petersburg.

CUBAN RAILWAYS, says the U. S. Consular Reports, for July, 1898, aggregate about 1,000 miles of main line, not including private branch lines to all important sugar estates. The most important company is the Ferrocarriles Unidos, with four lines connecting Havana with Matanzas, Batabano, Union and Guanajay. The Western Railway extends to Peurto de Golpe, 96 miles from Havana, and 10 miles from Pinar del Rio, the center of the tobacco district. The other lines join the towns of Cardenas and Santa Clara; Mantanzas and Murga and Matanzas and Guareiras; Concha and Cruces; Cienfuegos and Santa Clara; Caibarien and Placetas, Puerto Principe and Nuevitas, and the Guantanamo railway. A line, 8½ miles long, also connects Havana with Marianao. There are four cable lines connecting with Cuba, but only Havana, Cienfuegos and Santiago de Cuba are connected with these lines. The International Ocean Telegraph Co.'s cable runs from Havana to Florida; the Cuban Submarine Co. has a cable connecting Havana with Cienfuegos and Santiago de Cuba; the West Indian & Panama Co.'s cable connects Havana with Santiago de Cuba, Jamaica, Puerto Rico, the

Lesser Antilles, Isthmus of Panama; the Compagnie Francaise connects Havana with Santiago de Cuba, Haiti, Santo Domingo, Venezuela and Brazil.

THE NILGIRI RACK RAILWAY, now being built in India, starts from the Meltapoliyam Station, on the Madras Railway. The alinement is nearly straight for 4½ miles to the foot of the hills, at Kulhar Station, with easy curves and a steepest grade of 1 in 40. From Kulhar, which is 1,250 ft. above sea-level, to Coonor, 5,600 ft. elevation, the line rises with a grade of 1 in 12½, with curves as sharp as 328 ft. radius and 70% of the whole line in curve. On this railway there are 35 plate-girder bridges of 60 ft. span and 44 bridges of shorter span; the Burliar bridge has five 60-ft. spans and is 120 ft. above the water in the gorge. Most of these bridges are on curves of 328 ft. radius and on the steepest grade of 1 in 12½. The rack-bars, 10 ft. 2¾ ins. long each, are stamped out of steel. The four tank engines to be used were built by Bezer, Peacock & Co., and weigh 33 tons each, with 13 tons on driving axles, and 10-ft. rigid wheel-base. Each engine will pull 90 tons on the 1 to 40 grade, and 60 tons on the 1 to 12½ grade, and both engines and cars are fitted with powerful brakes. It is proposed to later carry this line over the hills to the port of Calicut, on the west coast of India, and to make connection with the meter-gage railways to the east.

BRAZILIAN MANGANESE ORE has been exported for the last four years. It comes from the district of Miguel Burnier, State of Morias Geraes, about 310 miles from Rio Janeiro. The mines are about 4,000 ft. above sea level, and they are worked by Italian and native labor. In 1897, the entire output of 8,800 tons went to Philadelphia. An analysis of the ore shows an average of 54.7% of metallic manganese, 0.021% sulphurous acid, and 0.077% of phosphoric acid.

A NEW PROCESS OF OBTAINING GREAT HEAT, in metallurgy, is described in "Stahl and Eisen" by Mr. Hans Goldschmidt. The process is based upon the utilization of the high temperature disengaged in the combustion of aluminum. The body to be heated is wrapped in an envelope made of a mixture of aluminum and metallic oxides in a pulverized state. This is then exposed to a temperature sufficient to decompose the oxides and burn the aluminum; and the interior of the packet is very rapidly raised in temperature with results comparable to the work of an electric furnace. The process appears to be especially applicable to the reduction of chrome. On account of the chemical effects resulting, we can substitute for the oxides, or oxidizing bodies, sulphur or sulphureous bodies. The aluminum may also be replaced by magnesium or carbide of calcium.

A MATCH PASTE, free from white phosphorus, and which will light on cloth or other substances, is wanted by the Belgian government, which offers a prize of 50,000 francs to the inventor. The competition is international and is open until Jan 1, 1899. M. Woesti is the President of the Adjudicating Commission, and his address is 2 Rue Laterati, Brussels.

COAL TESTING BY THE RONTGEN RAYS is a new application suggested by H. M. Couriot in a communication to the Paris Academie des Sciences. He states that carbon, in all its forms, is exceedingly transparent to the rays, while silica and silicates are opaque. By placing a lump of coal between a Crookes tube and a fluorescent screen, all the slag and clinker forming parts of the fuel can be detected. In this manner M. Couriot has tested anthracite and bituminous coal, lignite, coke and block fuel. The conglomerate character of the latter fuel is clearly shown; and in coke the particles of iron sulphide show as black spots on the screen. Rough lumps of coal, 1½ to 2 ins. thick, may be used, with an exposure of 5 minutes and with a coil having a 10-in. spark.

THE COPPER PRODUCTION of the world for four years, 1894-1897, inclusive, is given in two tables in "The Engineering and Mining Journal" of June 25, from which we extract the following, the figures being tons of 2,240 lbs.

	1894.	1895.	1896.	1897.
World's production	324,850	334,268	381,100	412,050
Production in the U. S.	163,394	177,881	214,149	227,763
Consumption in the U. S.	84,267	125,619	102,083	126,438

THE VALIDITY OF THE PATENT of C. J. Van Depoele, No. 424,695, April 1, 1890, for improvements in suspended switches and traveling contacts for electric railways, now owned by the General Electric Co., was sustained on June 23, 1898, by the U. S. Circuit Court, Eastern District of New York, and a perpetual injunction was decreed against the defendants. On Jan. 8, 1896, the U. S. Circuit Court of Appeals reversed a decision of the lower court against this patent, and remitted the case to the Circuit Court with instructions in favor of the complainant. The patent covers broadly the switch in overhead wires for electric railways, now in universal use. Two of the sustained claims are as follows:

3. The combination, with an overhead wire for receiving an underneath contact, of a switch-plate attached to the wire in about the same horizontal plane as the wire.

4. The combination of a track having switches, an overhead conductor above the track and having switches, and a car on the track provided with a contact-carrying arm arranged to engage the conductor at a point in rear of the front wheels of the car.

THE GREATEST DANGER of a severe loss by fire in a factory insured in mutual insurance companies, according to the report of the Boston Manufacturers' Mutual Fire Insurance Co. for the month of May, is the possibility that some valve in the automatic sprinkler service will be closed at the time when a fire breaks out. That this danger is not a slight one is shown by the fact that the company's inspectors during six months found 48 instances of sprinkler valves being wholly or partly closed, which ought to have been open. To avoid this source of danger it is recommended that all sprinkler valves should be sealed or strapped open and that each mill manager shall require an inspection and report upon the condition of the valves to be made once a week, such reports to be kept on record for revision by the inspectors of the insurance companies.

HOT-AIR MOTORS are discussed in "Dingler's Polytechniches Journal," for April 10, 1898. In attempts to improve existing machines Messrs. Lombaerde and Lecompte, of Paris, replace the air-compressor by an annular space around the motor cylinder itself. Mr. Kornboerfer, of Bohemia, is striving to maintain tightness and the lubrication of the cylinder at high temperatures. Mr. Ledin, a Swiss, proposes to employ as a motor-fluid a mixture of steam and the products of the combustion of petroleum in a closed vessel. Messrs. Rozer and Mazurier have patented a device for combining a hot-air and explosion motor, in such manner that the escaping gas of the one heats the air in the other motor.

THE COLONIAL POSSESSIONS of European states are given as follows in "Consular Reports" for June:

Country.	Area, sq. miles (—(1 = 1,000.)—) Mother-land.	Colonies.	Population (—(1 = 1,000.)—) Mother-land	Colonies.
Great Britain	121	16,662	39,825	322,000
France	204	2,505	38,520	44,290
German Empire	209	1,616	53,325	7,450
Portugal	36	810	5,050	10,215
Holland	13	783	4,930	34,210
Spain	198	405	17,300	9,800
Italy	111	242	31,290	195
Denmark*	15	87	2,175	130

*Including Faroe Islands, Iceland and Greenland.

BOOK REVIEWS.

PHYSICAL GEOGRAPHY OF NEW JERSEY.—By Rollin D. Salisbury. With Appendix by Cornelius Clarkson Vermeule. Vol. IV. of the Final Report of the State Geologist. Cloth, 6¼ x 10 ins.; pp. 170 + 200; 24 plates, 37 figures in text, large map in tube, and many tables. Address John C. Smock, State Geologist, Trenton, N. J.

This volume contains some of the matter given in the first volume of the present series, "Topography, Magnetism and Climate," which is now out of print. Part I. of the main work is devoted to a detailed description of the topography of the state, and Part II. to the history of the topography. The illustrations are made up of maps, diagrams, profiles and reproductions of photographic views, all well designed to aid in a ready understanding of the text. We have rarely seen a selection of views in a work of this kind which so truly illustrate the text, as distinguished from embellishment. These views do both. The colored relief map is on a scale of one mile to the inch, and is a very creditable piece of work.

The appendix contains a variety of useful information, mostly in statistical form, but conveniently arranged. Among this information may be mentioned bench-marks; elevations of prominent points and topographical features; drainage areas, forested areas and population of stream basins; areas and drainage areas of lakes and ponds and areas of tidal waters; yield of streams; areas of counties and townships; and detailed results of a magnetic survey of the state.

MONOGRAPH UPON RESERVOIRS AND THEIR EFFECTS ON THE FLOODS OF THE MISSISSIPPI SYSTEM.—By James A. Seddon, U. S. Assistant Engineer. Washington, Government Printing Office. Paper; 9 x 6 ins.; pp. 26. Maps and diagrams.

This monograph is the result of long and laborious investigation on the part of the author, and is based upon existing facts, instead of being a deduction from assumed or supposed conditions. For the Upper Mississippi System the period of study covers the years 1880-1885, inclusive; and for these years the stages and discharges of the Mississippi, Missouri and Ohio Rivers have been observed and plotted so as to show the combinations that make up the final floods at Cairo. A similar study covers the floods of the Lower Mississippi, for the years 1882-83-84, 1892-93, and 1897. This gives the stages and discharges at points of maximum outflow and inflow, from Cairo to Vicksburg, and shows the free and restrained outflow and the resulting changes. The map accompanying the flood data indicates the levee lines and distances subject to overflow, and the areas of the several swamp basins. From the material here made available, Mr. Seddon is enabled to, at least, approximately estimate the capacity of reservoir required for a given reduction of any flood; and to do this both for the Upper and Lower Mississippi systems. As to the Upper System, Mr. Seddon concludes that if any head water reservoirs are to be established with the view of reducing flood extremes at Cairo, this must be done wholly in the Ohio River basin; and before any intelligent estimate can be made of the ultimate effect of such reservoirs, the discharge data for this river must be more closely studied and subdivided and traced back to its sources.

The Lower Mississippi has an immense reservoir capacity in its swamp overflow; but these are of little value, as they are, for reducing or controlling flood levels. This lack of value does not arise from any want of capacity to take off water; but from their inability to hold it until after the flood period has passed. The author then suggests a system of cross levees, cutting the natural drainage area into a series of shallow reservoirs, with outlets under control. He discusses the question fully and generally estimates the capacity to be given to such a chain of reservoirs. The detailed location and dimensions he leaves for further consideration.

THE ALASKAN GOLD FIELDS AND THE OPPORTUNITIES THEY OFFER FOR CAPITAL AND LABOR.—By Sam. C. Dunham. Bulletin of the Department of Labor; Carroll D. Wright, Commissioner; No. 16. May, 1898. Washington: Government Printing Office. Paper, 9x6 ins.; pp. 297 to 507. Large map of Alaskan gold fields and smaller maps of particular localities.

To obtain trustworthy information relating to the opportunities for remunerative employment of American labor and capital in the Alaskan gold fields, Mr. Sam. C. Dunham, of the U. S. Department of Labor, was sent out to make an official investigation. He left Washington, D. C., on July 31, 1897, and his report brings matters up to Jan. 8, 1898. He commences his report by a brief account of the discovery of gold in this region; describes the four principal trails leading to the Yukon gold fields, and then presents in the form of a diary, the details, cost and incidents of his trip from Dyea to Dawson. This part of the report is of exceeding value to the would-be gold-seeker; for it tells him what to expect and how much each step towards the Yukon may cost him, in cash and in personal effort. He was exactly one month in reaching his destination; or, from Aug. 23 to Sept. 23, 1897. The separate gold fields are then taken up in detail and illustrated by maps of each. The report is so full of detail that it is impossible to generalize with profit to the reader; but Mr. Dunham freely quotes from and recommends as the best book yet written on the Yukon country, Mr. Wilson's "Guide to the Yukon Gold Fields," published in 1895.

A few facts of general interest may, however, be noted. The mean annual temperature of the Yukon Valley is roughly estimated at 23° F.; with 78° below zero as the greatest cold on record. Open water, even in the coldest weather is found on many of the tributaries of the Yukon, and many springs never freeze over. The annual rainfall in the valley is figured at about 25 ins., with 60 to 70 ins. on the coast. May, June and part of July bring delightful weather, on the lower Yukon; but the rest of the summer is very wet. Timber is abundant; the most valuable and largest tree being the white spruce, which attains a height of 50 to 100 ft., and a diameter of one to two feet. As indicated by annular fiber, this tree attains an enormous age; a tree 8 ins. in diameter often showing rings indicating 600 to 700 years of growth. This slow growth, due to climatic conditions, eliminates any hope of a new timber growth of any consequence when once the present timber supply is exhausted. The other more common trees are the birch, balsam poplar, willows and alders. The first is the only hard wood in the country, and the others are usually soft, rotten and valueless. The Yukon Valley has abundant capacity for producing root crops; but it is not yet known that oats, barley, wheat or rye, can be cultivated. It is highly improbable that this territory will ever become a self-supporting agricultural district; and its chief wealth lies in its fish, furs and gold.

The Yukon River itself is formed by the junction of the Lewes and Pelly rivers, and taking the first as its main source, the river is nearly 2,600 miles long. A number of steamers are now operated on this river, during the navigation season of four to five months, and the head of navigation is at Fort Selkirk, 2,210 miles above the mouth. The fare from St. Michaels, 60 miles across the bay from the Yukon mouth, to Dawson, 2,050 miles up the river, is $90. The up-stream freight, of which there is very little, is figured on a basis of 53 cts. per ton per running hour; and the down-stream freight at 55 cts. These figures mean $150 and $70 per ton respectively, between St. Michaels and Fort Selkirk. On the lower river, or 600 miles above the mouth, driftwood is entirely depended upon for fuel for the steamers, as all standing timber has been cut away by the ice coming down the river. But there is an abundance of good coal, further up, near Tawana, Circle City and Forty Mile. But the interested reader must obtain this report for himself to benefit by the patient work of Mr. Dunham; and the large folding map of the region contained in the report is essential to an intelligent study of the material which he presents.